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ON THE CONNECTION OF PRECESSION AND NUTATION WITH THE FIGURE OF THE EARTH.

By G. W. HILL.

Some difficulties have been encountered in reconciling the various values derived for the compression of the earth. On reading the discussions which have been published on this subject, it is suggested that they might possibly be removed if the formulas, on which the derivation depends, were made more nearly rigorous. In the present article I propose to supply some omissions in the theory of precession and nutation, one of the sources whence has been derived a value for the compression. The expressions hitherto given for the constant of precession and the coefficient of the principal term of nutation have been obtained by the substitution of elliptical values for the lunar coordinates. The only deviation from this mode of proceeding I have been able to find is in Prof. HARKNESS's *The Solar Parallax and its Related Constants*, where, in the first of his equations (158) for SERRET's $\frac{1}{a}$ he substitutes $\frac{1+\kappa'}{a}$, κ' standing for

$$(\tfrac{1}{6}+\tfrac{1}{4}e'^2)m^2 - \tfrac{179}{288}m^4 - \tfrac{97}{48}m^5$$

in DELAUNAY's notation. But the part of the constant of precession produced by lunar action and the coefficient of the principal term of nutation are augmented by about a 340th part through the solar perturbations of the lunar coordinates. Prof. HARKNESS's innovation brings us much nearer the truth, but is not quite rigorous. When the object is simply to show how these phenomena result from the forces in action, and an appeal is finally to be made to observation for the values of the constants involved, no great objection can be made to the old method. But when we wish to derive from these observed values the mass of the moon and the ratio of the moments of inertia of the earth it is important that the factors involved should be determined with some approach to rigor.

The differential equations for precession and nutation, first stated by POISSON, are

$$\frac{d\omega}{dt} = \frac{1}{Cn\sin\omega}\,\frac{dV}{d\psi}, \qquad \frac{d\psi}{dt} = -\frac{1}{Cn\sin\omega}\,\frac{dV}{d\omega},$$

$$V = -\tfrac{3}{2}(C-A)\left[\frac{m}{r^3}\sin^2\delta + \frac{m'}{r'^3}\sin^2\delta'\right].$$

Here ω denotes the obliquity of the equator to a fixed ecliptic, ψ the amount of retrograde motion of its node on this plane. C is the moment of inertia of the earth about its axis of rotation, A half the sum of the moments of inertia about the two principal axes lying in the plane of the equator. m and m' are the masses severally of the moon and sun, r and r' the distances of their centers from the center of the earth, and δ and δ' their declinations.

When we treat precession alone, it suffices to substitute for the terms $\frac{m}{r^3}\sin^2\delta + \frac{m'}{r'^3}\sin^2\delta'$ their non-periodic portions. In the case of the second of these, neglecting all periodic perturbations, we can assume that the sun moves about the earth in an ellipse whose elements are slowly changing. From the theory of elliptic motion we know that $\frac{a^3}{r^3}\cos 2f$ and $\frac{a^3}{r^3}\sin 2f$ have no non-periodic terms; also the addition of a function independent of ω and ψ to V does not impair its use for our purposes. Thus it is plain we may substitute for $\sin^2\delta'$

$$-\tfrac{1}{2}\cos^2\omega' = -\tfrac{1}{2}[\cos i\cos\omega - \sin i\sin\omega\cos(\psi+\theta)]^2,$$

where ω' denotes the obliquity of the actual equator to the actual ecliptic, and i the inclination, and θ the longitude of the node of the latter on the fixed ecliptic. And, for $\frac{a'^3}{r'^3}$, may be substituted its non-periodic term $(1-e'^2)^{-3/2}$, e' denoting the eccentricity of the earth's orbit.

If, with DELAUNAY, we denote the longitude and latitude of the moon by V and U, we have

$$\sin\delta = \cos\omega'\sin U + \sin\omega'\cos U\sin(V+\psi)$$

$$\frac{m}{r^3}\sin^2\delta = \frac{m}{r^3}\cos^2\omega'\sin^2 U + \frac{m}{r^3}\sin\omega'\cos\omega'\sin 2U\sin(V+\psi)$$
$$+\tfrac{1}{2}\frac{m}{r^3}\sin^2\omega'\cos^2 U - \tfrac{1}{2}\frac{m}{r^3}\sin^2\omega'\cos 2(V+\psi).$$

As it is evident that the two terms of the latter equation, which involve V, are wholly periodic, they may be rejected; and from the expression we may subtract $\frac{m}{r^3}\sin^2 U$, which does not contain ω or ψ. Thus, for precession, we may substitute for $\frac{m}{r^3}\sin^2\delta$,

$$\tfrac{1}{2}\frac{m}{r^3}\,[1-3\sin^2 U]\sin^2\omega'.$$

Let us denote the non-periodic term of $\frac{a^3}{r^3}\,[1-3\sin^2 U]$ by N. The value of this, corresponding to elliptic expressions for the lunar coordinates, is easily found. For the non-periodic term of $\frac{a^3}{r^3}$ is $(1-e^2)^{-3/2}$, and $\sin U$ is equal to the sine of the inclination multiplied by the sine of the true argument of latitude. Thus the elliptic value of N, in Delaunay's symbols, is

$$(1-e^2)^{-3/2}\,(1-6\gamma^2+6\gamma^4)$$

To obtain the part of N which arises from solar perturbation, we consider first the function $\frac{a^3}{r^3}$. Let $\delta\mathrm{r}$ denote the perturbation of $\frac{a}{r}$, so that

$$\frac{a^3}{r^3}=\left(\frac{a}{r_0}+\delta\mathrm{r}\right)^3=\frac{a^3}{r_0^3}+3\,\frac{a^2}{r_0^2}\,\delta\mathrm{r}+3\,\frac{a}{r_0}\,\delta\mathrm{r}^2+\delta\mathrm{r}^3$$

In this formula it is sufficient to put

$$3\,\frac{a^2}{r_0^2}=3+\tfrac{3}{2}e^2+\tfrac{9}{8}e^4+[6e+\tfrac{9}{4}e^2]\cos l+\tfrac{15}{2}e^2\cos 2l,$$

$$3\,\frac{a}{r_0}=3+[3e-\tfrac{3}{8}e^3]\cos l+3e^2\cos 2l.$$

We propose to compute N to terms of the seventh order inclusive, and shall make use of Delaunay's expressions for the lunar coordinates. However, in the case of $\frac{a}{r}$, the expression goes only to terms of the fifth order, and we need the non-periodic term of this coordinate to terms of the seventh order. Fortunately Adams has published the expression for this term to this degree of approximation (*Monthly Notices*, Vol. XXXVIII, p. 172). We also need the coefficient of $\cos l$ in the same coordinate to terms of the sixth order. To get this we resort to Pontécoulant's expression. His e and γ, however, differ from Delaunay's quantities denoted by the same symbols, and a comparison of their coefficients of $\sin l$ and $\sin F$, severally in the expressions for the moon's longitude and latitude, shows that, in order to obtain Delaunay's form for the coefficients, we ought to substitute for Pontécoulant's e the expression

$$\begin{aligned}&[1-\tfrac{3}{4}m^2+\tfrac{75}{128}m^3+\tfrac{6947}{512}m^4+\tfrac{1606525}{24576}m^5]e\\&\quad+[\tfrac{263}{32}m^2+\tfrac{51345}{1024}m^3]e^3+[\tfrac{9}{2}m^2+\tfrac{6125}{128}m^3]ee'^2\\&\quad+[\tfrac{51}{16}m^2-\tfrac{87}{8}m^3]\gamma^2e,\end{aligned}$$

and, for his γ, the expression

$$\begin{aligned}&[2-\tfrac{33}{64}m^2-\tfrac{241}{256}m^4+\tfrac{82495}{12288}m^5]\gamma-[1-\tfrac{55}{32}m^2+\tfrac{339}{128}m^3]\gamma^3\\&\quad-\tfrac{1}{4}\gamma^5-\tfrac{737}{256}m^2e^2\gamma-\tfrac{27}{4}m^2e'^2\gamma+e^2\gamma^3+\tfrac{7}{32}e^4\gamma\end{aligned}$$

Pontécoulant's expression for the coefficient of $\cos l$ in $\frac{a}{r}$ is (*Théorie Analytique*, Tom. IV, pp. 138, 276, 332).

$$[1-\tfrac{1}{8}e^2+\tfrac{1}{192}e^4+\tfrac{1}{6}m^2-\tfrac{645}{128}m^3-\tfrac{152129}{4608}m^4-\tfrac{3474907}{24576}m^5-(\tfrac{797}{96}m^2+\tfrac{23265}{512}m^3)e^2-(\tfrac{43}{8}m^2+\tfrac{8215}{128}m^3)e'^2-(\tfrac{83}{128}m^2-\tfrac{1707}{256}m^3)\gamma^2]e.$$

However, it must be noted that in the final result at p. 568 he has 315 instead of the 1707 at the end of this formula. I adopt the earlier stated number. Substituting for Pontécoulant's e and γ their values just given, we get as the coefficient of $\cos l$ in terms of Delaunay's constants,

$$\begin{aligned}&[1-\tfrac{7}{12}m^2-\tfrac{285}{64}m^3-\tfrac{45091}{2304}m^4-\tfrac{341017}{4096}m^5]e\\&\quad+[-\tfrac{1}{8}+\tfrac{19}{96}m^2+\tfrac{2295}{512}m^3]e^3+[-\tfrac{7}{8}m^2-\tfrac{1045}{64}m^3]ee'^2\\&\quad+[\tfrac{19}{32}m^2+\tfrac{1011}{64}m^3]\gamma^2e+\tfrac{1}{192}e^5\end{aligned}$$

Delaunay's value, as far as it goes, agrees with this, except that he has the terms $\tfrac{5}{2}\gamma^4e-\tfrac{5}{4}\gamma^2e^3$, overlooked by Pontécoulant.

By squaring and cubing $\delta\mathrm{r}$ as given by Delaunay, and preserving only the terms which are useful to us, we get

$$\begin{aligned}\delta\mathrm{r}^2=&\ \tfrac{19}{36}m^4+\tfrac{19}{6}m^5+\tfrac{10441}{864}m^6+\tfrac{15793}{432}m^7+[\tfrac{225}{128}m^2+\tfrac{3765}{256}m^3+\tfrac{2915423}{36864}m^4+\tfrac{540285}{1536}m^5]e^2\\&+[\tfrac{119}{24}m^4+\tfrac{171}{4}m^5]e'^2+[-2m^4-\tfrac{67}{6}m^5]\gamma^2+[\tfrac{225}{32}m^2+\tfrac{12705}{256}m^3]e^4\\&+[-\tfrac{225}{32}m^2-\tfrac{9555}{128}m^3]e^2\gamma^2+[\tfrac{1207}{128}m^2+\tfrac{68285}{512}m^3]e^2e'^2+[\tfrac{25}{9}-\tfrac{675}{32}m]e^2\gamma^4\\&+[\tfrac{225}{512}m^2+\tfrac{1215}{256}m^3]\,\frac{a^2}{a'^2}+[\tfrac{25}{32}-\tfrac{225}{32}m]e'^2\,\frac{a^2}{a'^2}\\&+[\tfrac{15}{8}m^3+\tfrac{3931}{288}m^4+\tfrac{32115}{512}m^5+(\tfrac{225}{32}m^2+\tfrac{1635}{32}m^3)e^2+\tfrac{55}{8}m^3e'^2-\tfrac{15}{2}m^3\gamma^2]e\cos l\\&+\tfrac{495}{128}m^3e^2\cos 2l\\ \delta\mathrm{r}^3=&\ \tfrac{55}{216}m^6+\tfrac{19}{12}m^7+[\tfrac{225}{256}m^4+\tfrac{2925}{512}m^5]e^2\end{aligned}$$

By the substitution of these values in the preceding equation we ascertain the non-periodic term of $\frac{a^3}{r^3}$; to which we annex the few periodic terms which are necessary for the complete determination of N:

$$\begin{aligned}\frac{a^3}{r^3}=&\ (1-e^2)^{-3/2}+\tfrac{1}{2}m^2-\tfrac{9}{32}m^4+\tfrac{55}{16}m^5+\tfrac{2159}{96}m^6+\tfrac{1997}{24}m^7\\&+[\tfrac{483}{128}m^2+\tfrac{8595}{256}m^3+\tfrac{814965}{4096}m^4+\tfrac{3695593}{4096}m^5]e^2-[6m^4+\tfrac{67}{2}m^5]\gamma^2\end{aligned}$$

$$\begin{aligned}
&+\left[\tfrac{3}{4}m^2+\tfrac{153}{64}m^4+\tfrac{1485}{32}m^5\right]e'^2+\left[\tfrac{1845}{64}m^2+\tfrac{51615}{256}m^3\right]e^4\\
&-\left[\tfrac{213}{16}m^2+\tfrac{21015}{128}m^3\right]e^2\gamma^2+\left[-3m^2+\tfrac{27}{8}m^3\right]\gamma^4+\tfrac{15}{16}m^2e'^4\\
&+\left[\tfrac{3333}{128}m^2+\tfrac{185055}{512}m^3\right]e^2e'^2-\tfrac{15}{4}e^4\gamma^2+\left[\tfrac{135}{8}-\tfrac{2025}{32}m\right]e^2\gamma^4\\
&+\left[\tfrac{963}{512}m^2+\tfrac{4095}{256}m^3\right]\frac{a^2}{a'^2}+\left[\tfrac{75}{32}-\tfrac{675}{32}m\right]e'^2\frac{a^2}{a'^2}\\
&+3e\cos l+\tfrac{9}{2}e^2\cos 2l+\left[6m^2-9m^3-\tfrac{45}{2}e^2\right]\gamma^2\cos 2F+\left[-\tfrac{15}{2}+\tfrac{405}{16}m\right]\gamma^2e\cos(2F-l)\\
&+\tfrac{141}{8}m\gamma^2e\cos(2F+l)+\left[3m^2+\tfrac{19}{2}m^3+\tfrac{137}{6}m^4+\left(\tfrac{135}{8}m+\tfrac{1941}{32}m^2\right)e^2-\tfrac{15}{2}m^2e'^2-6m^2\gamma^2\right]\cos 2D\\
&+\left[\tfrac{45}{8}m+\tfrac{657}{32}m^2\right]e\cos(2D-l)+\tfrac{147}{16}m^2e\cos(2D+l)+\tfrac{21}{2}m^2e'\cos(2D-l')\\
&-\tfrac{3}{2}m^2e'\cos(2D+l')-9m^2\gamma^2\cos(2D-2F)
\end{aligned}$$

For computing the periodic development of $\sin^2U$, it is sufficient to take

$$\sin^2U = U^2-\tfrac{1}{3}U^4+\tfrac{2}{45}U^6$$

And let us suppose that $U = U_0+U_1$, U_0 denoting the elliptic portion, and U_1 the perturbational portion. Then, employing the symbol δ to denote the peturbational part.

$$\begin{aligned}
\delta(\sin^2U)&=\left(2U_0-\tfrac{4}{3}U_0^3+\tfrac{4}{15}U_0^5\right)U_1+\left(1-2U_0^2\right)U_1^2-\tfrac{4}{3}U_0U_1^3\\
&=\sin 2U_0\cdot U_1+\cos 2U_0\cdot U_1^2-\tfrac{4}{3}U_0U_1^3
\end{aligned}$$

But, on making $U_0=2\gamma\sin F$ and $U_1=\tfrac{3}{4}\gamma m\sin(2D-F)$, it is perceived that the last term of the second member contains no constant part; hence we neglect it; and for $\cos 2U_0$ it suffices to substitute its constant term $1-4\gamma^2$. Thus

$$\delta(\sin^2U) = \sin 2U_0\cdot U_1+(1-4\gamma^2)U_1^2$$

For $\sin 2U_0$ it is sufficient to write the expression

$$\begin{aligned}
\sin 2U_0 = {}&\left[4\gamma-4\gamma e^2-8\gamma^3\right]\sin F\\
&+4\gamma e\sin(F+l)-4\gamma e\sin(F-l)-\tfrac{1}{2}\gamma e^2\sin(F-2l)
\end{aligned}$$

We obtain the needed expression for U_1 from DELAUNAY by subtracting his value of U_0 (Vol. I. p. 58), from his value of U (Vol. II, p. 862). It is necessary to take all the inequalities of the second and third orders with one of the fourth, but their coefficients must be carried to terms severally of the fifth and fourth orders inclusive. Thus.

$$\begin{aligned}
U_1 = {}&\left[\tfrac{3}{4}m+\tfrac{9}{32}m^2\right]\gamma e'\sin(F-l')\\
&-\left[\tfrac{3}{4}m-\tfrac{69}{32}m^2\right]\gamma e'\sin(F+l')\\
&-\left[\tfrac{1}{2}m^2-\tfrac{21}{8}m^3\right]\gamma e\sin(F+l)\\
&+\left[\tfrac{189}{32}m^2+\tfrac{375}{32}m^3-\tfrac{135}{32}me^2+\tfrac{135}{8}m\gamma^2\right]\gamma e\sin(F-l)\\
&+\left[-\tfrac{5}{4}+\tfrac{135}{32}m\right]\gamma e^2\sin(F-2l)\\
&+\left[\tfrac{11}{8}m^2+\tfrac{59}{12}m^3+\tfrac{135}{16}me^2-\tfrac{3}{8}m\gamma^2\right]\gamma\sin(2D+F)\\
&+\left[\tfrac{15}{4}m+\tfrac{241}{16}m^2\right]\gamma e\sin(2D+F-l)\\
&+\left[\tfrac{3}{4}m+\tfrac{25}{16}m^2+\tfrac{2957}{768}m^3+\tfrac{84703}{9216}m^4\right.\\
&\qquad+\left(\tfrac{27}{16}m+\tfrac{423}{64}m^2\right)e^2-\left(\tfrac{15}{8}m+\tfrac{199}{16}m^2\right)e'^2\\
&\qquad\left.+\left(\tfrac{9}{8}m-\tfrac{175}{32}m^2\right)\gamma^2\right]\gamma\sin(2D-F)\\
&+\left[\tfrac{7}{4}m+\tfrac{255}{32}m^2\right]\gamma e'\sin(2D-F-l')\\
&-\left[\tfrac{3}{4}m+\tfrac{115}{32}m^2\right]\gamma e'\sin(2D-F+l')\\
&+\left[\tfrac{3}{4}m+\tfrac{23}{16}m^2\right]\gamma e\sin(2D-F+l)\\
&+\left[3m+\tfrac{105}{8}m^2\right]\gamma e\sin(2D-F-l)
\end{aligned}$$

For the elliptic value of $\sin^2U_0$ it suffices to take

$$\begin{aligned}
\sin^2U_0 = {}&2\gamma^2-2\gamma^4-2\gamma^2\cos 2F\\
&+4\gamma^2e\cos(F-l)-4\gamma^2e\cos(F+l)
\end{aligned}$$

By performing the multiplications we get

$$\begin{aligned}
\sin 2U_0\cdot U_1 = {}&-\left[\tfrac{205}{16}m^2+\tfrac{459}{16}m^3\right]e^2\gamma^2\\
&+\left[\tfrac{5}{16}+\tfrac{945}{128}m\right]e^4\gamma^2-\tfrac{135}{4}me^2\gamma^4\\
&+\left[\tfrac{173}{16}m^2+\tfrac{291}{16}m^3+\left(\tfrac{5}{2}-\tfrac{135}{8}m\right)e^2+\tfrac{135}{4}m\gamma^2\right]\gamma^2e\cos l\\
&+\left[-\tfrac{5}{2}+\tfrac{135}{16}m\right]\gamma^2e^2\cos 2l\\
&+\left[-\tfrac{3}{2}m-\tfrac{3}{8}m^2+\tfrac{273}{128}m^3+3me^2+\tfrac{15}{4}me'^2\right]\gamma^2\cos 2D\\
&-\tfrac{7}{2}m\gamma^2e'\cos(2D-l')+\tfrac{3}{2}m\gamma^2e'\cos(2D+l')\\
&-3m\gamma^2e\cos(2D+l)+\left[3m+\tfrac{39}{4}m^2\right]\gamma^2e\cos(2D-l)\\
&+\tfrac{3}{2}m\gamma^2\cos(2D-2F)
\end{aligned}$$

$$\begin{aligned}
U_1^2 = {}&\left[\tfrac{9}{32}m^2+\tfrac{75}{64}m^3+\tfrac{5175}{1024}m^4+\tfrac{60425}{3072}m^5\right]\gamma^2\\
&+\left[\tfrac{837}{64}m^2+\tfrac{14865}{128}m^3\right]e^2\gamma^2\\
&+\left[\tfrac{31}{32}m^2+\tfrac{795}{128}m^3\right]e'^2\gamma^2+\left[\tfrac{27}{32}m^2-\tfrac{183}{64}m^3\right]\gamma^4\\
&+\left[\tfrac{25}{32}-\tfrac{675}{128}m\right]e^4\gamma^2\\
&+\left[\tfrac{45}{16}m^2+\tfrac{351}{16}m^3\right]\gamma^2e\cos l
\end{aligned}$$

The sum of the three parts, of which it is composed, gives

$$\begin{aligned}
\sin^2U = {}&\left[2+\tfrac{9}{32}m^2+\tfrac{75}{64}m^3+\tfrac{5175}{1024}m^4+\tfrac{60425}{3072}m^5\right]\gamma^2\\
&+\left[\tfrac{17}{64}m^2+\tfrac{11193}{128}m^3\right]e^2\gamma^2\\
&+\left[\tfrac{31}{32}m^2+\tfrac{795}{128}m^3\right]e'^2\gamma^2-\left[2+\tfrac{9}{32}m^2+\tfrac{183}{64}m^3\right]\gamma^4\\
&+\left[\tfrac{35}{32}+\tfrac{135}{64}m\right]e^4\gamma^2-\tfrac{135}{4}me^2\gamma^4\\
&+\left[\tfrac{109}{8}m^2+\tfrac{321}{8}m^3+\left(\tfrac{5}{2}-\tfrac{135}{8}m\right)e^2+\tfrac{135}{4}m\gamma^2\right]\gamma^2e\cos l\\
&+\left[-\tfrac{5}{2}+\tfrac{135}{16}m\right]\gamma^2e^2\cos 2l-2\gamma^2\cos 2F\\
&+4\gamma^2e\cos(2F-l)-4\gamma^2e\cos(2F+l)\\
&+\left[-\tfrac{3}{2}m-\tfrac{3}{8}m^2+\tfrac{273}{128}m^3+3me^2+\tfrac{15}{4}me'^2\right]\gamma^2\cos 2D\\
&-\tfrac{7}{2}m\gamma^2e'\cos(2D-l')+\tfrac{3}{2}m\gamma^2e'\cos(2D+l')\\
&+\left[3m+\tfrac{39}{4}m^2\right]\gamma^2e\cos(2D-l)-3m\gamma^2e\cos(2D+l)\\
&+\tfrac{3}{2}m\gamma^2\sin(2D-2F)
\end{aligned}$$

By multiplying the series given for $\dfrac{a^3}{r^3}$ by that for $1-3\sin^2U$, and retaining only the non-periodic terms, we obtain the following expression for N (we prefer to write the portion which arises from elliptic values of the coordinates in its finite form).

$$\begin{aligned}
N = {}&(1-e^2)^{-3/2}(1-6\gamma^2+6\gamma^4)+\tfrac{1}{2}m^2-\tfrac{9}{32}m^4+\tfrac{55}{16}m^5+\tfrac{2159}{96}m^6+\tfrac{1997}{24}m^7\\
&+\left[\tfrac{483}{128}m^2+\tfrac{8595}{256}m^3+\tfrac{814965}{4096}m^4+\tfrac{3695593}{4096}m^5\right]e^2\\
&+\left[\tfrac{3}{4}m^2+\tfrac{153}{64}m^4+\tfrac{1485}{32}m^5\right]e'^2+\left[\tfrac{41}{32}m^2-\tfrac{69}{64}m^3-\tfrac{9273}{1024}m^4-\tfrac{67819}{3072}m^5\right]\gamma^2\\
&+\left[\tfrac{1845}{64}m^2+\tfrac{51615}{256}m^3\right]e^4+\left[\tfrac{713}{64}m^2+\tfrac{3369}{64}m^3\right]e^2\gamma^2+\left[-\tfrac{329}{32}m^2+\tfrac{165}{64}m^3\right]\gamma^4\\
&+\tfrac{15}{16}m^2e'^4+\left[\tfrac{3333}{128}m^2+\tfrac{185055}{512}m^3\right]e^2e'^2+\left[\tfrac{79}{32}m^2+\tfrac{459}{128}m^3\right]e'^2\gamma^2\\
&-\left[\tfrac{145}{32}+\tfrac{135}{32}m\right]e^4\gamma^2+\left[\tfrac{195}{8}-\tfrac{1041}{32}m\right]e^2\gamma^4+\left[\tfrac{963}{512}m^2+\tfrac{4095}{256}m^3\right]\frac{a^2}{a'^2}+\left[\tfrac{75}{32}-\tfrac{675}{32}m\right]e'^2\frac{a^2}{a'^2}
\end{aligned}$$

The expression, given for this quantity in *Astronomical Papers*, Vol. IV, p. 515, and intended to be exact to terms of the sixth order, is rendered erroneous by a misprint and some omissions in PONTÉCOULANT.

The principal term of nutation arises from the term

$$\frac{m}{r^3}\sin\omega'\cos\omega'\sin 2U\sin(V+\psi)$$

of $\frac{m}{r^3}\sin\delta$, and, using always DELAUNAY's notation, has the argument $\psi+h$. Hence we must find the coefficient of $\cos(\psi+h)$ in $\frac{a^3}{r^3}\sin 2U\sin(V+\psi)$, which we will denote by N'. The means of deriving this coefficient I have given (*Astronomical Papers*, Vol. III, p. 233). We have only to sum the parts of the term (39), and double and reverse the sign of the whole to have the value of N'. But the approximation is carried only to terms of the fifth order inclusive. It seems desirable to go one order further, and therefore I propose to complete the nine sources of terms worked out pp. 216–229 by the addition of terms which are of the sixth order. It is necessary then to add to the development of R at p. 216 the terms in three dimensions of δr, δV and δU. However, it is discovered that two only of these contribute anything to the desired coefficient, viz.:

$$\tfrac{1}{2}\frac{d^3R_0}{dr^2dU}\,\delta r^2\,\delta U+\frac{d^3R_0}{dr\,dV\,dU}\,\delta r\,\delta V\,\delta U$$

We now repeat the nine divisions of pp. 217–229 with the necessary extensions, so far as they are needed for the computation of this term:

I. For the two factors it suffices to put

$$\begin{aligned}\frac{dR_0}{dr}&=[-3\gamma+\tfrac{15}{2}\gamma^3-\tfrac{3}{2}\gamma e^2]\cos(\psi+h)-3\gamma e\cos(\psi+h\pm l)\\&\quad+3\gamma\cos(\psi+h+2F)-3\gamma e\cos(\psi+h+2F-l)\\ \delta r&=(\tfrac{1}{6}+\tfrac{1}{4}e'^2)m^2-\tfrac{179}{288}m^4-\tfrac{97}{48}m^5-(\tfrac{7}{12}m^2+\tfrac{285}{64}m^3)e\cos l\\&\quad+(-5e^2+\tfrac{135}{8}e^2m+2m^2-3m^3)\gamma^2\cos 2F\\&\quad+(-\tfrac{3}{2}+\tfrac{135}{16}m)\gamma^2e\cos(2F-l)\end{aligned}$$

The coefficient of $\cos(\psi+h)$ in the product is

$$\begin{aligned}&-\tfrac{15}{4}\gamma^3e^2+\tfrac{405}{32}\gamma^3e^2m+(-\tfrac{1}{2}\gamma+\tfrac{17}{4}\gamma^3+\tfrac{3}{2}\gamma e^2-\tfrac{3}{4}\gamma e'^2)m^2\\&\quad+(-\tfrac{9}{2}\gamma^3+\tfrac{855}{64}\gamma e^2)m^3+\tfrac{179}{96}\gamma m^4+\tfrac{97}{16}\gamma m^5\end{aligned}$$

II. For the two factors it suffices to put

$$\begin{aligned}\frac{dR_0}{dV}&=-\gamma\sin(\psi+h+2F)+\tfrac{1}{2}\gamma e\sin(\psi+h+2F-l)\\ \delta V&=[-\tfrac{25}{4}\gamma^2e^2+\tfrac{675}{32}\gamma^2e^2m+\tfrac{11}{4}\gamma^2m^2-\tfrac{231}{64}\gamma^2m^3]\sin 2F\\&\quad+[-5\gamma^2e+\tfrac{135}{8}\gamma^2em]\sin(2F-l)\end{aligned}$$

The coefficient of $\cos(\psi+h)$ in the product is

$$\tfrac{15}{8}\gamma^3e^2-\tfrac{405}{64}\gamma^3e^2m-\tfrac{11}{8}\gamma^3m^2+\tfrac{231}{128}\gamma^3m^3$$

III. For the two factors it suffices to put

$$\begin{aligned}\frac{dR_0}{dU}&=-\tfrac{5}{2}e\sin(\psi+h+F+l)-\tfrac{1}{2}e\sin(\psi+h+F-l)\\&\quad-\tfrac{5}{8}e^2\sin(\psi+h+F-2l)\\ \delta U&=[-\tfrac{1}{2}\gamma em^2-\tfrac{21}{8}\gamma em^3]\sin(F+l)\\&\quad+[-5\gamma^3e+\tfrac{5}{4}\gamma e^3+(\tfrac{135}{8}\gamma^3e-\tfrac{135}{32}\gamma e^3)m\\&\qquad+\tfrac{189}{32}\gamma em^2+\tfrac{375}{32}\gamma em^3]\sin(F-l)\\&\quad+[-\tfrac{5}{4}\gamma e^2+\tfrac{135}{32}\gamma e^2m]\sin(F-2l)\end{aligned}$$

The coefficient of $\cos(\psi+h)$ in the product is

$$\begin{aligned}&\tfrac{5}{4}\gamma^3e^2+\tfrac{5}{64}\gamma e^4-(\tfrac{135}{32}\gamma^3e^2+\tfrac{135}{512}\gamma e^4)m\\&\quad-\tfrac{189}{128}\gamma e^2m^2+\tfrac{45}{128}\gamma e^2m^3.\end{aligned}$$

IV. For the two factors it suffices to put

$$\begin{aligned}\tfrac{1}{2}\frac{d^2R_0}{dr^2}&=-3\gamma\cos(\psi+h)-\tfrac{3}{2}\gamma e\cos(\psi+h\pm l)\\ \delta r^2&=\tfrac{225}{128}e^2m^2+\tfrac{3765}{256}e^2m^3+\tfrac{19}{36}m^4+\tfrac{19}{6}m^5\\&\quad+\tfrac{15}{8}em^3\cos l\end{aligned}$$

The coefficient of $\cos(\psi+h)$ in the product is

$$-\tfrac{675}{128}\gamma e^2m^2-\tfrac{12015}{256}\gamma e^2m^3-\tfrac{19}{12}\gamma m^4-\tfrac{19}{2}\gamma m^5$$

V. For the two factors it suffices to put

$$\begin{aligned}\tfrac{1}{2}\frac{d^2R_0}{dV^2}&=\tfrac{1}{2}\gamma\cos(\psi+h)+\tfrac{3}{4}\gamma e\cos(\psi+h\pm l)\\&\quad-\tfrac{1}{2}\gamma\cos(\psi+h+2F)\\ \delta V^2&=(\tfrac{225}{32}e^2+\tfrac{9}{2}e'^2)m^2+(\tfrac{8715}{128}e^2-\tfrac{33}{32}\gamma^2)m^3\\&\quad+\tfrac{121}{128}m^4+\tfrac{649}{96}m^5+\tfrac{165}{32}em^3\cos l\\&\quad+\tfrac{99}{32}\gamma^2m^3\cos 2F\end{aligned}$$

The coefficient of $\cos(\psi+h)$ in the product is

$$\begin{aligned}&(\tfrac{225}{64}\gamma e^2+\tfrac{9}{4}\gamma e'^2)m^2+(\tfrac{9705}{256}\gamma e^2-\tfrac{165}{128}\gamma^3)m^3\\&\quad+\tfrac{121}{256}\gamma m^4+\tfrac{649}{192}\gamma m^5\end{aligned}$$

VI. For the two factors it suffices to put

$$\begin{aligned}\tfrac{1}{2}\frac{d^2R_0}{dU^2}&=-2\gamma\cos(\psi+h+2F)+2\gamma\cos(\psi+h)\\ \delta U^2&=\tfrac{9}{32}\gamma^2m^2+\tfrac{75}{64}\gamma^2m^3+\tfrac{33}{32}\gamma^2m^3\cos 2F\end{aligned}$$

The coefficient of $\cos(\psi+h)$ in the product is

$$\tfrac{9}{16}\gamma^3m^2+\tfrac{21}{16}\gamma^3m^3$$

VII. For the two factors it suffices to put

$$\begin{aligned}\frac{d^2R_0}{dr\,dV}&=-3\gamma\sin(\psi+h+2F)+3\gamma e\sin(\psi+h\pm l)\\ \delta r\,\delta V&=-\tfrac{75}{128}em^3\sin l-\tfrac{9}{8}\gamma^2m^3\sin 2F\end{aligned}$$

The coefficient of $\cos(\psi+h)$ in the product is

$$\tfrac{27}{16}\gamma^3m^3$$

VIII. For the factors it suffices to put

$$\begin{aligned}\frac{d^2R_0}{dr\,dU}&=[-3+12\gamma^2+\tfrac{3}{2}e^2]\sin(\psi+h+F)\\&\quad-6e\sin(\psi+h+F+l)-\tfrac{15}{2}\gamma^2\sin(\psi+h-F)\\ \delta r&=[\tfrac{15}{4}e^2m+(1-2\gamma^2+\tfrac{189}{16}e^2-\tfrac{5}{2}e'^2)m^2\\&\qquad+\tfrac{19}{6}m^3+\tfrac{131}{18}m^4]\cos 2D\\&\quad-\tfrac{3}{2}e'm^2\cos l'+\tfrac{7}{2}e'm^2\cos(2D-l')\\&\quad+\tfrac{1}{2}e'm^2\cos(2D+l')+[\tfrac{15}{8}em+\tfrac{187}{32}em^2]\cos(2D-l)\\&\quad+\tfrac{33}{16}em^2\cos(2D+l)-3\gamma^2m^2\cos(2D-2F)\end{aligned}$$

and the necessary terms of δU may be selected from the expression for U_1 previously given. The product of the two latter factors is

$$\delta r\delta U = [-\tfrac{45}{64}\gamma e^2 m^2 + (-\tfrac{3}{8}\gamma - \tfrac{9}{8}\gamma^3 + \tfrac{117}{64}\gamma e^2 - \gamma e'^2)m^3 - \tfrac{41}{32}\gamma m^4 - \tfrac{3829}{1536}\gamma m^5]\sin F - \tfrac{63}{64}\gamma e m^3 \sin(F+l)$$

And the coefficient of $\cos(\psi+h)$ in the product of the three factors is

$$\tfrac{135}{128}\gamma e^2 m^2 + (\tfrac{9}{16}\gamma - \tfrac{63}{32}\gamma^3 - \tfrac{9}{128}\gamma e^2 + \tfrac{3}{2}\gamma e'^2)m^3 + \tfrac{123}{64}\gamma m^4 + \tfrac{3829}{1024}\gamma m^5$$

IX. For the factors it suffices to put

$$\frac{d^2R_0}{dVdU} = [-1+4\gamma^2 - \tfrac{1}{2}e^2]\cos(\psi+h+F) - \tfrac{5}{2}e\cos(\psi+h+F+l) - \tfrac{1}{2}e\cos(\psi+h+F-l) - \tfrac{5}{2}\gamma^2\cos(\psi+h-F)$$

$$\begin{aligned}\delta V = {} & [(-\tfrac{3}{4}\gamma^2 + \tfrac{75}{16}e^2)m + (\tfrac{11}{8} - \tfrac{47}{16}\gamma^2 + \tfrac{1101}{64}e^2 - \tfrac{55}{16}e'^2)m^2 + \tfrac{59}{12}m^3 + \tfrac{893}{72}m^4]\sin 2D \\ & -3e'm\sin l' + \tfrac{77}{16}e'm^2\sin(2D-l') - \tfrac{11}{16}e'm^2\sin(2D+l') \\ & +[\tfrac{15}{4}em + \tfrac{263}{16}em^2]\sin(2D-l) + \tfrac{17}{8}em^2\sin(2D+l) \\ & +[\tfrac{9}{4}\gamma^2 m - \tfrac{11}{2}\gamma^2 m^2]\sin(2D-2F)\end{aligned}$$

and as before the necessary terms of δU may be taken from U_1 given previously. The product of the two latter factors is

$$\begin{aligned}\delta V\delta U = {} & [(\tfrac{9}{16}\gamma^3 + \tfrac{1845}{128}\gamma e^2 + \tfrac{9}{4}\gamma e'^2)m^2 + (\tfrac{33}{64}\gamma - \tfrac{255}{128}\gamma^3 + \tfrac{8283}{64}\gamma e^2 + \tfrac{355}{64}\gamma e'^2)m^3 \\ & + \tfrac{989}{256}\gamma m^4 + \tfrac{219951}{12288}\gamma m^5]\cos F + \tfrac{87}{16}\gamma e m^3\cos(F+l) \\ & + [\tfrac{45}{32}\gamma e m^2 + \tfrac{195}{16}\gamma e m^3]\cos(F-l)\end{aligned}$$

And the coefficient of $\cos(\psi+h)$ in the product of the three factors is

$$-(\tfrac{9}{32}\gamma^3 + \tfrac{1935}{256}\gamma e^2 + \tfrac{9}{8}\gamma e'^2)m^2 - (\tfrac{33}{128}\gamma - \tfrac{177}{128}\gamma^3 + \tfrac{19119}{256}\gamma e^2 + \tfrac{355}{128}\gamma e'^2)m^3 - \tfrac{989}{512}\gamma m^4 - \tfrac{219951}{24576}\gamma m^5$$

X. For the factors it suffices to put

$$\tfrac{1}{2}\frac{d^3R_0}{dr^2dU} = -3\sin(\psi+h+F), \quad \delta r^2\delta U = -\tfrac{1}{8}\gamma m^5 \sin F$$

The coefficient of $\cos(\psi+h)$ in the product is $\tfrac{3}{16}\gamma m^5$

XI. For the factors it suffices to put

$$\frac{d^3R_0}{dr\,dV\,dU} = -3\cos(\psi+h+F), \quad \delta r\,\delta V\,\delta U = \tfrac{11}{128}\gamma m^5\cos F$$

The coefficient of $\cos(\psi+h)$ in the product is $-\tfrac{33}{256}\gamma m^5$

By adding the terms arising from these eleven sources, and multiplying the sum by —2, and joining the result to the part of N' arising from the substitution of elliptic values for the coordinates, we obtain the following expression.

$$\begin{aligned}N' = {} & 2(1-e^2)^{-3/2}\gamma(1-2\gamma^2)(1-\gamma^2)^{1/2} \\ & + [m^2 - \tfrac{39}{64}m^3 - \tfrac{381}{256}m^4 + \tfrac{128023}{12288}m^5]\gamma \\ & + [\tfrac{1949}{128}m^2 + \tfrac{17937}{128}m^3]e^2\gamma + [-\tfrac{3}{4}m^2 + \tfrac{163}{64}m^3]e'^2\gamma \\ & + [-\tfrac{101}{16}m^2 + \tfrac{281}{64}m^3]\gamma^3 + [\tfrac{5}{4} - \tfrac{135}{32}m]e^2\gamma^3 \\ & + [-\tfrac{5}{32} + \tfrac{135}{256}m]e^4\gamma\end{aligned}$$

For deriving the numerical values of N and N' we put

$$m = 0.07480133, \quad e = 0.0548993, \quad \gamma = 0.04488663,$$

$$e' = 0.01677106, \quad \frac{a}{a'} = 0.002576$$

all from Delaunay, except the last, which is modified to correspond to the value 8″.81 for the solar parallax. Then we have

$$N = 0.99241874 + 279762^{2} + 7045^{4} + 4949^{5} + 2420^{6} + 842^{7} + 308 = 0.995372$$

$$N' = 0.08972677 + 25115^{3} - 1145^{4} + 648^{5} + 914^{6} + 491 = 0.089987$$

The first terms of these expressions are the values which result from the employment of elliptic values for the moon's coordinates; the following terms are the aggregates of the terms of each order, the figure above denoting the order; and the last terms, obtained by induction, are added to complete the series. In Peters's *Numerus Constans Nutationis*, p. 27, 0.99212 and 0.08967 are given as the values of these two quantities.

In seeking readily applicable expressions for P the constant of luni-solar precession and the coefficient of the principal term of the lunar nutation of the obliquity $\mathcal{N}$, we call to mind that the first is usually given for a tropical year, as finding a more general use in the theory of the stars. Moreover, for the constants $\frac{m}{a^3}$ and $\frac{m'}{a'^3}$, putting M for the mass of the earth, we substitute their equivalents in terms of the times of revolution of the moon and sun about the earth. Let us suppose then that T, T^{I}, T^{II}, T^{III} and T^{IV} denote severally the times of the rotation of the earth on its axis, of revolution of the earth about the sun, of the moon about the earth, the tropical revolution of the moon's nodes and the tropical year. Then we shall have the following expressions for P and $\mathcal{N}$:

$$P = 1944000'' \frac{T^{\mathrm{IV}}}{T^{\mathrm{I}}}\frac{T}{T^{\mathrm{I}}}\frac{C-A}{C}\left[\frac{m'}{M+m'}(1-e'^2)^{-3/2} + \frac{m}{M+m}\left(\frac{T^{\mathrm{I}}}{T^{\mathrm{II}}}\right)^2 N\right]\cos\omega'$$

$$\mathcal{N} = \tfrac{3}{2}\frac{m}{M+m}\frac{TT^{\mathrm{III}}}{T^{\mathrm{II}\,2}}\frac{C-A}{C}N'\cos\omega'$$

The first factor of P is simply 3π in sexagesimal seconds of arc. All the quantities entering into the right members of these equations are known with precision, except the two ratios $\frac{C-A}{C}$ and $\frac{m}{M+m}$. Let us deduce numerical expressions for P and $\mathcal{N}$ for the epoch 1850. We assume

$$\frac{T}{T^{\mathrm{I}}} = \frac{1}{366.25636}, \quad \frac{T^{\mathrm{IV}}}{T^{\mathrm{I}}} = \frac{365.2422}{365.25636}, \quad \frac{T^{\mathrm{II}}}{T^{\mathrm{I}}} = 0.07480133$$

$$\frac{T^{\mathrm{III}}}{T^{\mathrm{II}}} = \frac{6798.353}{27.321661}, \quad \frac{m'}{M+m'} = \frac{327214}{327215}, \quad \omega' = 23^\circ\,27'\,31''.65$$

For convenience, writing the common logarithms of the numerical factors in brackets, we have

$$P = [3.6876097]\frac{C-A}{C} + [5.9375945]\frac{m}{M+m}\frac{C-A}{C}$$

$$\mathcal{N} = [5.3654318]\frac{m}{M+m}\frac{C-A}{C}$$

These expressions give the quantities immediately in seconds of arc.

When it is desired to get $\frac{C-A}{C}$ and $\frac{m}{M+m}$ from given values of P and N, the following formulas serve:

$$\frac{C-A}{C} = [6.3123903]P - [6.8845530]N$$

$$\frac{m}{M+m} = \frac{[8.3221779]N}{P-[0.5721627]N}$$

As an illustration let us take STRUVE's value of the luni-solar precession and PETERS's value of the nutation constant. Reduced to the epoch 1850, they may be set down at 50″.38227 and 9″.22355. Then,

$$\frac{C-A}{C} = 0.003272995, \quad \frac{m}{M+m} = \frac{1}{82.31500}$$

OBSERVATIONS OF WINNECKE'S COMET AND COMET 1892 I,

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

1892 Cincinnati M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			Winnecke's Comet.					
	h m s		m s	′ ″	h m s	° ′ ″		
June 20 10 5 33	1	8 , 6	+0 18.47	−4 45.6	9 56 34.96	+39 28 46.3	9.774	0.648
22 9 15 18	2	8 , 6	+1 47.35	−2 33.4	9 44 39.92	+38 37 11.5	9.767	0.594
25 9 13 20	3	8 , 6	−2 35.51	−4 19.7	9 22 29.46	+36 50 3.8	9.758	0.666
			Comet 1892 I.					
July 14 10 45 36	4	6 , 6	+0 56.90	−6 21.7	0 58 44.87	+49 23 1.8	n9.842	0.651
19 9 53 19	5	8 , 6	−1 18.66	+5 0.2	1 1 37.40	+50 13 7.7	n9.831	0.723
Sept. 17 8 10 9	6	7 , 8	−0 4.31	+2 57.2	0 20 24.66	+50 31 10.7	n9.815	0.114
22 7 48 51	7	10 , 8	−0 21.06	−0 23.0	0 14 2.41	+49 30 35.3	n9.802	0.118

Mean Places for 1892.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	9 56 16.28	+0.21	+39 33 21.6	+10.3	Lund A.G.Z.
2	9 42 52.45	+0.12	+38 39 35.0	+ 9.9	Cincinnati Mer. Cir. 1 obs.
3	9 25 4.95	+0.02	+36 54 14.3	+ 9.2	Lund A.G.Z.
4	0 57 47.09	+0.88	+49 29 28.8	− 5.3	Oe. Arg. 1042
5	1 2 54.99	+1.07	+50 8 12.0	− 4.5	Oe. Arg. 1138 ; Rogers A.G.Z. 523
6	0 20 26.02	+2.95	+50 28 0.0	+13.5	B.B. VI. +50°71 ; Rogers A.G.Z. 171
7	0 14 20.55	+2.92	+49 30 43.0	+15.3	B.B. VI, +49°50

RING-MICROMETER OBSERVATIONS OF COMET *f* 1892 (*HOLMES*).

MADE AT COLUMBIA COLLEGE OBSERVATORY, NEW YORK, WITH THE RUTHERFURD 13-INCH EQUATORIAL,

BY HAROLD JACOBY AND J. T. MONELL.

1893 Columbia Coll. M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ	Obs.
h m s			m s	′ ″	h m s	° ′ ″			
Jan. 21 9 20 35	1	3	−1 0.87	+21 41.1	1 28 42.77	+33 39 23.4	9.666	0.463	Jac.
9 36 55	1	3	−1 0.63	+21 40.1	1 28 43.01	+33 39 22.4	9.683	0.496	Mon.
25 8 37 40	2	3	−0 3.01	− 6 38.9	1 34 12.50	+33 41 25.0	9.624	0.391	Jac.

Mean Places for 1893.0 of Comparison-Stars.

*	α	Reduction	δ	Reduction	Authority
	h m s	s	° ′ ″	″	
1	1 29 44.51	−0.87	+33 17 34.1	+8.2	Paris 1963
2	1 34 16.42	−0.91	+33 47 55.7	+8.2	Weisse's Bessel I, 726

According to the above observations, SCHULHOF's ephemeris (*A.N.* 3140) requires a correction of +0s.35 and −2″.5 on Jan. 21, −0s.1 and +3″ on Jan. 25.

Jan. 21, the comet was circular, with a strong central condensation, and bright stellar nucleus.

Jan. 25, the comet had lost its stellar nucleus, but still had a slight central condensation. It was circular.

OBSERVATIONS OF COMET *g* 1892 (*BROOKS*),

MADE AT THE VASSAR COLLEGE OBSERVATORY,

BY MARY W. WHITNEY AND MARY S. WAGNER, STUDENT-ASSISTANT.

1893 Poughkeepsie M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$		Obs.
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ	
h m s			m s	′ ″	h m s	° ′ ″			
Jan. 19 8 1 2	1	4	−2 1.80	+4 6.3	22 58 51.08	+48 53 25.8	9.812	0.413	W
10 7 45	2	4	−0 17.28	+0 59.6	22 59 32.62	+48 46 12.9	9.807	0.724	Wa
20 7 55 11	3	6	+0 36.10	+8 32.1	23 5 37.19	+47 31 21.8	9.796	0.403	W
21 8 1 15	4	5	+0 5.50	−2 22.3	23 11 50.08	+46 11 39.2	9.787	0.437	W
9 57 14	5	4	−1 11.23	−1 20.9	23 12 19.9	+46 8.8	9.793	0.709	Wa

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	23 0 55.09	−2.21	+48 49 15.1	+4.4	Oe. Arg. 25113
2	22 59 52.12	−2.22	+48 45 9.0	+4.3	Oe. Arg. 25083–4
3	23 5 2.94	−2.15	+47 22 45.6	+4.1	Struve 2796 (1830)
4	23 11 46.67	−2.09	+46 14 5.6	+4.1	Rümker 10971
5	23 13 33.2	−2.08	+46 10.1	+4.2	DM. 45°4190

The position of comparison-star no. 4, of the series published Feb. 8, differs considerably from its position as deduced from Prof. ROGERS's observations in the Cambridge A.G. Zone. Prof. ROGERS made five observations of this star. The following are the coordinates of the comet as referred to the Cambridge position.

Jan. 16^d 7^h 31^m 31^s , α = 22^h 33^m 19^s.19 , δ = 53° 21′ 12″.8

OBSERVATIONS OF COMETS,

MADE AT GOODSELL OBSERVATORY, NORTHFIELD, MINN., WITH THE 16-INCH REFRACTOR AND FILAR MICROMETER.

BY H. C. WILSON.

[Communicated by WM. W. PAYNE, Director.]

1892–93 Northfield M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
				COMET *f* 1892 (HOLMES).				
h m s			m s	′ ″	h m s	° ′ ″		
Dec. 10 7 17 19	1	9 , 6	−1 18.91	+ 4 3.6	0 46 34.31	+35 13 17.8	*n*8.273	0.143
16 6 47 15	2	6 , 6	−0 7.01	+ 6 50.5	0 50 15.10	+34 45 53.4	*n*8.618	0.168
23 7 39 27	3	5 , 4	+4 24.94	+ 2 24.2	0 55 42.68	+34 19 34.6	9.094	0.212
Jan. 5 7 17 24	4	10 , 6	+0 39.97	− 7 2.6	1 8 41.53	+33 48 38.6	9.196	0.249
7 7 49 11	5	11 , 4	+1 6.52	+ 1 19.2	1 10 58.96	+33 45 42.2	9.368	0.302
16 8 21 19	6	10 , 6	+1 3.11	−10 13.7	1 22 3.33	+33 39 12.9	9.526	0.400
18 7 35 40	7	12 , 6	−0 8.91	+ 1 27.8	1 24 38.49	+33 38 54.2	9.422	0.331
*8 17 37	7	11 , 6	−0 6.75	+ 1 26.9	1 24 40.65	+33 38 53.3	9.530	0.402
				COMET *g* 1892 (BROOKS).				
Jan. 7 9 31 28	8	9 , 6	−0 8.24	+ 9 32.6	19 50 10.11	+65 25 41.6	9.869	0.813
12 7 7 2	9	8 , 6	+0 32.18	− 2 2.9	21 41 50.	+59 32.0	9.904	0.213
7 7 2	10	8 , 6	−0 16.16	− 1 5.8	21 41 51.	+59 31.9	9.904	0.213
16 6 45 17	11	6 , 4	−2 23.43	+ 1 38.1	22 33 31.29	+53 15 28.1	9.784	0.052
				COMET *a* 1892 (SWIFT).				
Jan. 16 9 26 47	12	9 , 6	−1 17.84	− 1 1.8	0 22 28.38	+25 53 19.3	9.651	0.675

* Observation by A. G. SIVASLIAN, Student in Astronomy.

Mean Places for 1892.0 and 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 47 50.53	+2.72	+35 8 46.0	+28.2	Leyden A.G. Zones 235,78
2	0 50 19.46	+2.65	+34 38 35.0	+28.0	Leyden A.G. Zones
3	0 51 15.17	+2.57	+34 16 42.4	+28.0	Leyden A G. Zones 231,73 ; 328,42
4	1 8 2.32	—0.76	+33 55 32.6	+ 8.6	Leyden A.G. Zones 343,40 ; 347,13
5	1 9 53.22	—0.78	+33 44 14.5	+ 8.5	Leyden A.G. Zones 343,43 ; 393,12
6	1 21 1.06	—0.84	+33 49 18.3	+ 8.3	Leyden A.G. Zones 343,48 ; 347,24
7	1 24 48.24	—0.84	+33 37 18.0	+ 8.4	Leyden A.G.Zones 212,64 ; 343,52 ; 393,20
8	19 50 22.08	—3.73	+65 16 14.4	— 5.4	Christiania A.G.C. 3097
9	21 11 21.	—3.12	+59 34.0	+ 1.8	DM. 59°2414. 9M.5
10	21 42 30	—3.12	+59 33.0	+ 1.8	DM. 59°2417. 9M.5
11	22 35 57.23	—2.51	+53 13 45.9	+ 4.1	Greenw. 10-yr. Cat. 3807
12	0 23 47.32	—1.10	+25 54 17.8	+ 3.4	Lalande 643

NOTES ON COMET *f* 1892 (HOLMES.)

1892 Dec. 10. Comet very faint; nucleus about 12 mag.; nebulosity about 1′ in diameter.

Dec. 14. Very faint, but large in 5-inch finder. Tail extends across the whole diameter of the field of view, 1° 15′. The width just back of the nucleus is about 20′.

Dec. 16. Very faint but large. Slight condensation about nucleus. Diff. of R.A. measured with micrometer.

Dec. 23. Very faint but easily seen in 5-inch finder; about 15′ in diameter. In 16-inch but little could be seen except the condensation about the nucleus, 1′ or less in diameter. When the light was turned off for some time, I could trace the nebulosity to a distance of about 5′ on the preceding side of the nucleus and farther on the following side.

1893 Jan. 5. Exceedingly faint. In the large telescope, with no light for a considerable time, by sweeping I can see very extensive nebulosity, but exceedingly faint. There is a small brighter patch about 30″ in diameter, which I take to contain the nucleus. It is slightly condensed in the center. In the finder the nuclear condensation is not visible, but the comet is quite large. I can trace the tail to at least one diameter of the field (1° 15′) and the width at the head is about one-third diameter of the field.

Jan. 7. Appearance same as on Jan. 5.

Jan. 12. Very faint nebulosity seen with 5-inch finder. In the large telescope a bright star (DM 33° 220, 6M.3) hid the nuclear condensation from view.

Jan. 16. I was astonished to find in the place of the nucleus what looked like a very bright planetary nebula. Took micrometer measures first from a 10M star near it, to be sure it was not a nebula. In 10 minutes motion in R.A. was evident. The comet was small and round, about 30″ in diameter, with a dense nucleus. At first the nucleus was very hazy, but later was sharply defined, and about 8 magnitude. The comet was watched from 7h.30 to 10h p.m., with an intermission of half an hour while SWIFT's comet was observed.

Jan. 18. Comet bright. Nucleus very dense, but not stellar. Coma more than 1′ in diameter, slightly elongated in P.A. 45°±; fainter than on the 16th. Faint trace of tail extending 5′ or more in P.A. 45°. Nucleus larger than but not quite so bright as the comparison star (DM. 33° 246, 8M.1).

Jan. 21. At 7, p.m, comet bright and larger than on the 18th. Nucleus fainter; = 10M star. Coma bright in center, fading out towards the edges, oval in shape, with the nucleus eccentric. Diameter of coma about 2′. Outside of this I can see very faint nebulosity, which is probably the old comet. It extends about 4′ from the nucleus in P.A. 225°, and further in the opposite direction. It is very difficult to find where the comet ends and the dark sky begins. There is a new tail developing from the new coma in P.A. 45°±

NOTES ON COMET *g* 1892 (BROOKS.)

Jan. 7. Comet bright, with well-defined nucleus and short tail.

Jan. 16. Comet bright, with sharply-defined nucleus, 8M.5. Tail extending beyond field of large telescope. Easily seen in 5-inch finder but not very conspicuous.

NOTES ON COMET *a* 1892 (SWIFT.)

Jan. 9. Invisible in 5-inch finder. In 16-inch small and quite condensed in center.

Jan. 16. Comet faint, round, 30″± in diameter, with slight central condensation.

OBSERVATION OF COMET *f* 1892 (*HOLMES*),

MADE AT THE LEANDER McCORMICK OBSERVATORY,

BY ORMOND STONE.

1893 L. McC. M.T.		*	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ
	h m s		m s	′ ″	h m s	° ′ ″
Feb. 13	9 42 26	20 , 4	+1 2.70	—0 52.1	2 2 59.25	+34 8 10.6

Mean Place for 1893.0 of Comparison-Star.

α	Reduction	δ	Reduction	Authority
h m s	s	° ′ ″	″	
2 1 57.57	—1.02	+34 8 54.8	+7.9	Leyden Zones 397,42 ; 398,28

Comet faint, round, 2′ or 3′ in diameter.

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MAXIMA AND MINIMA OF VARIABLE STARS, OBSERVED IN 1892,

BY PAUL S. YENDELL.

VIII.

1623. *T Camelopardalis.*

$\alpha = 4^{h}\ 26^{m}\ 4^{s}, \qquad \delta = +65°\ 53'$ (1855).

This is another of the list of stars, some of the results of my observations of which were published in no. 279 of this Journal. ESPIN (*Astron. Nachr.*, Vol. 127, p. 111) announces it as variable, and says the variability has been confirmed at Harvard College Observatory; the star is not in the *Durchmusterung.*

Between 1891 Dec. 1 and 1892 April 19, I looked for it six times without seeing it, from which I infer that during that time it was certainly below $11^{\mathrm{M}}.0$. On 1892 Oct. 14, I found it about $9^{\mathrm{M}}.6$; since this date, I have observed it twenty-four times in all — the last observation being 1893 Jan. 20.

The star varied little during the first month's observations, but after Nov. 13 it rose steadily and rapidly to $8^{\mathrm{M}}.2$, which magnitude it reached Dec. 11; it continued at about the same brightness until 1893 Jan. 2, but on Jan. 16 it showed a marked decrease, and on Jan. 20, when last observed, had fallen to $8^{\mathrm{M}}.7$; the observations indicate a maximum of $8^{\mathrm{M}}.2$ on 1892 Dec. 28. The star is a trifle redder than *R Andromedae*, or about 6 of CHANDLER'S scale of redness.

906. *R Trianguli.*

This star has been under observation since 1892 Aug. 21, when it was just held in a very clear sky, its magnitude being estimated at $12^{\mathrm{M}}.4 \pm$; it rose pretty rapidly, with some fluctuations, to a maximum of $5^{\mathrm{M}}.9$, which is indicated in my observations on 1892 Nov. 28. The decrease has not been so steady and rapid as the increase, though the maximum is pretty definitely indicated; after decreasing to $6^{\mathrm{M}}.7$, the star remained at nearly the same light from 1892 Dec. 11 to 1893 Jan. 2. On Jan. 20, when last observed, it had fallen to about $8^{\mathrm{M}}.0$.

The interval between the last maximum and this one is 262^{d}; this accords well with the provisional elements published by myself in this Journal, Vol. XII, p. 90.

1717. *V Tauri.*

Eight observations of *V Tauri*, from 1892 Sept. 20 to Nov. 11, indicate a maximum of $9^{\mathrm{M}}.0$ to $9^{\mathrm{M}}.5$ on 1892 Oct. 15.

1981. *S Camelopardalis.*

The variability of this star was confirmed by me in this Journal, Vol. XII, p. 114. Observations have been continued upon the star, and indicate a minimum of $10^{\mathrm{M}}.7 \pm$ to have occurred 1892 Dec. 18; the star was at no time lost sight of. The interval between this minimum and the one occurring on Feb. 18 of the same year is 304 days.

2815. *U Geminorum.*

During the recent maximum of *U Geminorum* I secured six rather scattered observations, as follows:

1892 Dec. 9.354 not seen; limit of visibility $11^{\mathrm{M}} \pm$.

	M	W
11.344	9.8	4
.385	9.8	4
15.347	9.2	4
16.330	9.3	4
20.337	10.0	4
22.350	10.7	4
26.319	not seen; limit of visibility $< 10^{\mathrm{M}}$; moon at 1st quar.	

The second observation on Dec. 11 was made as a check upon the first, which was taken at a low altitude of the star, the sky being somewhat hazy also; these, in view of the observation of Dec. 9, appear to belong to the rising branch of the curve; an interval of three cloudy evenings prevented observation until the 15th, and a similar gap, from the same cause, occurs between Dec. 16 and 20.

MR. GEORGE KNOTT, in a private letter, informs me that he found the star $9^{\mathrm{M}}.5$ on Dec. 12, and about the same on the following night. Taking these in connection with my own observations, it seems probable that the maximum was passed Dec. 15.

7192. *Z Cygni.*

I have fifteen observations of this star from 1892 July 30 to 1893 Jan. 21. On the first-named date its light was estimated at $9^{\mathrm{M}}.7$; on Aug. 16, it was looked for but not seen, the limit of vision being estimated as $< 11^{\mathrm{M}}.0$. On Oct. 19, it was, by eye-estimate, $9^{\mathrm{M}}.5$; after this latter observation it rose steadily to a maximum of $8^{\mathrm{M}}.0$, which is indicated on 1892 Dec. 7. The first three observations seem to point to a minimum about the middle of August.

7257. *R Sagittae.*

Forty-two observations of *R Sagittae*, from 1892 June 1 to Nov. 23, indicate two maxima and three minima, as follows:

Maxima	M	Minima	M
1892 July 20.0	8.6	1892 June 22.3	9.5
Sept. 18.0	8.9	Aug. 29.0	9.5
		Oct. 24.0	9.5

At the last observation, 1892 Nov. 23, the star was apparently well on its way to a maximum, having risen to $9^{M}.0$.

7259. *R S Cygni.*

I have twenty-two observations of *R S Cygni*. At the first, on 1892 July 25, its light was about $7^{M}.8$; it decreased steadily until Oct 19, when it was estimated at $10^{M}.0$; the next observation, on Nov. 11. showed a marked increase, which has continued until observations on the star were discontinued, the last being 1893, Jan. 21, $9^{M}.0$.

7299. *U Cygni.*

Twenty-five observations, from 1892 Aug. 7 to 1893 Jan. 21, indicate a minimum of $9^{M}.6$ on 1892 Sept. 9. and a maximum of $8^{M}.6$ on 1892 Dec. 7.

7428. *V Cygni.*

V Cygni was observed from 1892 Oct. 24 to 1893 Jan. 21; a maximum of $8^{M}.8$ occurring 1892 Nov. 25. When last observed it had dropped nearly to $10^{M}.0$.

7754. *W Cygni.*

A sharply marked minimum of this star, $6^{M}.7$, occurred 1892 Dec. 22; when last observed, 1893 Jan. 16, it had risen fully half a magnitude.

7795. *R V Cygni.* (592 Bir.)

Since my announcement of the variability of this star (Vol. XII, p. 155), it has passed a minimum of $9^{M}.0$ on 1892 Dec. 16. This is confirmed by the observations of Mr. Parkhurst, communicated in a recent private letter.

8153. *R Lacertae.*

R Lacertae was looked for and not seen, on five occasions, from 1892 July 25 to Oct. 10, the limit of vision being $11^{M}.0$ to $11^{M}.5$. On Nov. 11 it was fairly held, and estimated at $11^{M}.5$; including this observation. it was seen on eight evenings, the last being 1892 Dec. 26; a maximum of $9^{M}.2$, on Dec. 5, is indicated by these observations. On 1893 Jan. 17 the star was found to have fallen below the grasp of my telescope.

The designations of the variables 1623, 1981, and 7795 are taken in advance, through the courtesy of Dr. Chandler, from his forthcoming Catalogue of Variable Stars.

Dorchester, Mass., 1893 *Jan.* 29.

MICROMETRIC OBSERVATIONS OF THE SATELLITE OF *NEPTUNE*,

MADE WITH THE 36-INCH REFRACTOR OF THE LICK OBSERVATORY,

By E. E. BARNARD.

The following observations of the satellite of *Neptune* have been made with the filar micrometer of the 36-inch equatorial. They refer to the center of *Neptune*, the disc of the planet being bisected in the observations with the micrometer wire.

With the great telescope the satellite was a bright and easy object to measure.

Upon examining the planet on October 2, the satellite presented the appearance of a close double star, being then in extremely close proximity to a small star. The two objects finally became so close during the observation as not to be separately distinguishable.

I have also measured the positions of two small stars seen near the planet on 1892 November 13, and 1893 January 8. The one seen January 8 was very faint on a first-class night. It was, however, distinctly visible.

The observations are all in Standard Pacific Time, which is eight hours slow of Greenwich.

The circle for reading revolutions of the micrometer-screw reads up to 110. In the measures of distance the threads were set perpendicular to the line between *Neptune* and the satellite by the position-circle.

1892 *October* 2.

Observations of the close conjunction of the satellite of *Neptune* with a fixed star.

Distance between the Satellite and the Star.

$13^{h}\ 53^{m}\ 22^{s}$	$28^{r}.962$	$0''.52$	2 obs.

Threads interchanged.

$13^{h}\ 55^{m}\ 47^{s}$	$29^{r}.077$	$0''.62$	2 obs.

Position-Angle of the Star.

	Circle	P.A.	
$14^{h}\ 0^{m}\ 0^{s}$	$154^{r}.8$	$326^{\circ}.1$	2 obs. star n. of satellite

The small star was about one-half magnitude brighter than the satellite. Magnifying power = 520 diameters.

$14^{h}\ 6^{m}$. The satellite and star are too close to measure. It is all but impossible to separate them.

During the measures for the position of the satellite ($14^{h}\ 26^{m}$ to $14^{h}\ 32^{m}$), it was impossible to separate the two with either 700 or 520 diameters.

At $14^{h}\ 40^{m}$, with 520 diameters, the satellite was perhaps visible very close s.p. the star.

At $16^{h}\ 15^{m}$ returned to *Neptune*. The satellite and star widely separate.

Though this was an exceedingly close conjunction, there was no actual occultation.

(*Neptune*—Satellite). *Ja*

h m s	r	″	
14 26 40	30.460	—14.32	Coincidence of threads
14 27 50	20.405	—13.78	= $29^{r}.014$

Setting of position-circle for the above = 188°.7.

Position-Angle of Satellite.

h m s	Circle °	P.A. °	
14 29 40	277.6	88.9	Parallel = 278°.7
14 31 15	276.4	87.7	
14 32 15	275.7	87.0	

1892 *November* 13.

Position-Angle of the Satellite.

h m s	Circle °	P.A. °	
10 47 20	248.6	61.2	Parallel = 277°.4
10 49 37	249.0	61.6	
10 52 17	249.2	61.8	

Distance from Center of *Neptune*.

h m s	r	″	
10 55 5	31.013	16.97	Coincidence of threads
10 56 50	31.068	17.52	= $29^{r}.299$
10 58 5	31.036	17.20	
11 3 50	31.000	16.84	

Setting of position-circle for distance = 339°.5

1892 *November* 18.

Position-Angle of the Satellite.

h m s	Circle °	P.A. °	
14 13 23	100.0	91.9	Parallel = 278°.1
14 15 13	99.8	91.7	
14 16 38	100.1	92.0	

Distance of Satellite from Center of *Neptune*.

h m s	r	″
14 19 8	30.699	13.95
14 20 38	30.675	13.71
14 22 28	30.695	13.90

Threads interchanged.

h m s	r	″	
14 23 33	27.888	13.89	Coincidence of threads
14 26 3	27.932	13.46	= $29^{r}.291$
14 28 3	27.910	13.38	

Setting of position-circle for distances = 190°.

Satellite bright. but wind shaking telescope.

1892 *November* 20.

Position-Angle of the Satellite.

h m s	Circle °	P.A. °	
13 19 50	186.1	358.0	Parallel = 278°.1
13 22 35	186.1	358.0	
13 24 0	185.6	357.5	
13 25 40	184.6	356.5	

Distance of Satellite from Center of *Neptune*.

h m s	r	″	
13 28 32	30.272	9.71	No wind; observations
13 30 1	30.300	9.98	good
13 31 7	30.291	9.90	

Threads interchanged.

h m s	r	″	
13 32 15	28.320	9.61	Coincidence of threads
13 33 25	28.295	9.86	= $29^{r}.291$
13 34 28	28.280	10.01	

Setting of position-circle for distances = 94°.0

1892 *December* 9.

Position-Angle of Satellite.

h m s	Circle °	P.A. °	
10 26 35	269.2	259.4	Parallel = 279°.8
10 29 25	268.7	258.9	
10 30 25	268.2	258.4	
10 32 15	268.2	258.4	

Distance from Center of *Neptune*.

h m s	r	″
10 35 37	1.589	15.56
10 36 55	1.603	15.70
10 38 30	1.575	15.52

Threads interchanged.

h m s	r	″	
10 40 15	108.476	15.27	Coincidence of threads
10 41 45	108.460	15.43	= $0^{r}.018$
10 42 50	108.453	15.50	

Setting of position-circle for distances, = 358°.0.

1892 *December* 16.

Position-Angle of Satellite.

h m s	Circle °	P.A. °	
8 3 24	223.4	220.4	Parallel = 273°.0
8 5 29	223.7	220.7	
8 5 49	223.5	220.5	
8 7 54	223.6	220.6	

Distance of Satellite from Center of *Neptune*.

h m s	r	″	
8 10 34	108.509	14.94	Coincidence of threads
8 12 24	108.488	15.15	= $0^{r}.018$
8 13 29	108.565	14.39	

Threads interchanged.

h m s	r	″
8 14 49	1.563	15.30
8 16 29	1.526	14.93
8 17 39	1.645	16.11

Setting of position-circle for distances = 313°.5.

Seeing very poor, wind shaking telescope; but observations considered good.

1893 *January* 8.

Position-Angle of Satellite.

h m s	Circle °	P.A. °	
10 54 31	239.5	234.2	Parallel = 275°.3
10 55 44	239.2	233.9	
10 56 14	238.8	233.5	
10 57 19	240.0	234.7	

Distance of Satellite from Center of *Neptune*.

h m s	r	″	
10 58 46	1.701	16.54	Coincidence = $0^{r}.034$
10 59 21	1.770	17.19	
11 1 4	1.771	17.20	

Threads interchanged.

h m s	r	″
11 0 39	108.279	17.38
11 1 29	108.313	17.04
11 2 9	108.365	16.53

Setting of position-circle for distance = 329°.0.

1893 *January* 13.

Position-Angle of Satellite.

h m s	Circle °	P.A. °	
11 1 11	273.3	268.1	Parallel = 275°.2
11 3 54	273.3	268.1	
11 5 44	274.2	269.0	
11 6 37	273.8	268.6	

Distance of the Satellite from Center of *Neptune*.

h m s	r	″	
11 9 29	108.681	13.41	Coincidence = $0^{r}.035$
11 10 59	108.652	13.70	
11 12 11	108.662	13.60	

Threads interchanged.

h m s	r	″
11 14 20	1.407	13.60
11 15 35	1.406	13.58
11 16 26	1.411	13 63

Setting of position-circle for the distances = 183°.3.
Observations good.

1893 *January* 20.

Position-Angle.

h m s	Circle °	P.A. °	
8 6 18	59.1	230.6	Parallel = 278°.8.
8 8 20	58.9	230.1	
8 9 28	59.8	231.0	
8 10 33	58.3	229.5	

Distance from Center of *Neptune*.

h m s	r	″	
8 13 50	1.731	16.96	Coincidence of threads = $0^{r}.018$
8 15 28	1.714	16.80	
8 16 43	1.671	16.37	

Threads interchanged.

h m s	r	″
8 18 23	108.412	15.90
8 19 11	108.373	16 29
8 20 16	108.368	16.34

Setting of position-circle for distances = 149°.0.

Mt. Hamilton, 1893 *Jan.* 21.

1892 *November* 13.

Observations of *Neptune* and a small Star.

Position-Angle of the Object.

h m s	Circle °	P.A. °	
11 6 0	269.0	261.6	(1 obs.)

Distance from the Center of *Neptune*.

h m s	r	″	
11 8 50	31.384	20.65	(1 obs.)

The object was much fainter than the satellite; seeing very poor.

1893 *January* 8.

Observations of *Neptune* and a very faint Star.

Telescope West of Pier.

(*Neptune*—∗) $\Delta\delta$.

h m s	r	″
9 43 19	2.810	+27.49
9 46 35	2.784	+27.23

(*Neptune*—∗) $\Delta\alpha$.

h m s	r	″
9 55 1	0.721	+ 6.83

Telescope East of Pier.

(*Neptune*—∗) $\Delta\alpha$.

h m s	r	″
10 28 24	109.238	+ 7.88
10 33 34	109.425	+ 6.03

(*Neptune*—∗) $\Delta\delta$.

h m s	r	″
10 54 29	2.621	+26.62

Not seen after this.

The star was about $16\frac{1}{2}^{\rm M}$, and though it could be steadily seen by occulting *Neptune*, it was excessively difficult to bisect. It was south following the satellite.

ON THE NOMENCLATURE OF RECENTLY DISCOVERED VARIABLES,

BY S. C. CHANDLER.

To avert the danger of confusion in the lettering of the variables, a partial list is given, below, of the letters assigned in the forthcoming catalogue. This communication covers only those constellations in which conflict is likely to arise by a diverse notation. As soon as the variability of others has been established, the letters to be assigned them will be similarly published. The rule requiring such independent proof of variability in all cases, as the criterion for the assignment of letters, has been faithfully adhered to in the new catalogue, as it was in the first catalogue and its supplement. So far as I know, no objection to its rigorous application has been raised in any quarter, where the vital necessity of keeping our knowledge of this branch of astronomy clear of confusion is sufficiently appreciated, and the nature of the influences which unfortunately tend to reversion from a condition of order to one of chaos, is intelligently understood and deplored.

The principal reason for strictness in this matter lies in the fact that a large proportion of the stars which are announced as variable prove not to be so, upon investigation. This is unfortunate, and it is to be sincerely hoped that it will at some time be remedied by the prevalence of a more critical standard among those who busy themselves with the subject; so that it will ultimately become as discreditable to announce a discovery of variability which is not afterwards confirmed, as it now is in other departments of astronomy to state a fact which is not verified. But while the present state of things exists it must be recognized and provided for.

The temporary abstention from the use of a letter causes no hardship or inconvenience in practice, because all the unconfirmed stars are to be given in the supplementary list of the catalogue; and the number in parentheses, according to the notation provided in the supplement to the catalogue (*A.J.* no. 216), supplies a perfectly convenient working notation for the use of observers, and for indexing.

Some notes are required with regard to the notation adopted below, to obviate the confusion which has unfortunately arisen, or is likely to arise, from some of the letters employed in the *Vierteljahrsschrift* list (xxvii, 222). The star there called *T Camelopardalis* is not variable, according to YENDELL's observations up to this time, while this observer has confirmed the variability of the star called *T* in the list below; and the latter notation has already come into use and cannot now be displaced. Similarly the star *S Canum venaticorum* of the *VJS* list has not yet been confirmed. The star called *W Bootis* in the *VJS* list (14^h 19^m 54^s, +5° 14′.2) has, in the first place, not been confirmed; in the second, there are already in my first catalogue a *W* and an *X Bootis*, both of which stars are certainly variable according to both YENDELL's observations and my own; and, in the third place, the star is not in *Bootes* but in *Virgo*, so that, even if its variability should be confirmed before that of any other in the same constellation, its name will be *RS Virginis* and not *W Bootis*. Further the *VJS* list calls the *Nova* in *Auriga*, *U Aurigae*, whereas the notation *T Aurigae* has already come into use for this object, as has also that of *U Aurigae* for another star, given in the list below. The variability of the other stars to which letters have been prematurely assigned in the *VJS* has not been confirmed, so far as I know, and, one of them at least, will bear another letter than the one there given, even if the variability be confirmed, since there is a candidate which has the priority.

		1855 h	m	s	°	′
678	*U Persei*,	1	50	0	+54	7.0
691	*V Persei*,	1	52	6	+56	2
906	*R Trianguli*,	2	28	16	+33	37.8
1623	*T Camelopardalis*,	4	26	4	+65	53
1953	*T Aurigae*,	5	22	41	+30	19.9
1981	*S Camelopardalis*,	5	25	22	+68	42.5
2313	*U Aurigae*,	5	32	37	+31	57
3128	*R Pyxidis*,	8	39	23	−27	40.5
5758	*X Herculis*,	15	58	18	+47	38.4
6005	*S Draconis*,	16	39	49	+55	11.8
6834	*V Aquilae*,	18	56	40	− 5	53.7
7085	*RT Cygni*,	19	39	33	+18	25.5
7783	*RU Cygni*,	21	35	46	+53	40.0
7795	*RV Cygni*,	21	37	18	+37	21.2
7909	*R Piscis austrini*,	21	55	27	−28	44.9
8594	*V Cephei*,	23	49	44	+82	23.0

ON A NEW VARIABLE IN *AQUILA*.

($\alpha = 18^h\ 56^m\ 39^s.6$; $\delta = -5°\ 35'.5$ 1855.0)

By EDWIN F. SAWYER.

I wish to announce that I find the S.DM. star 5°4858 to be variable. The star was first observed (in connection with my revision of the magnitudes in SCHÖNFELD's *Southern Durchmusterung* from 7.0 to 7.8*) on August 29, 1890, and estimated to be 7^M.9, the S.DM. magnitude being 7.0. This difference of nearly a magnitude between the estimates of SCHÖNFELD and myself led me to suspect variation. A second observation, on September 21, found the star at least 8^M.0.

A press of other work prevented further observations until last year (1892) when observations on August 15 and 23 found the star still faint, or about 8^M.0, and apparently demonstrated its constancy of light. As a final observation, however, the magnitude was again estimated on September 26, and I was surprised to find that the star had undoubtedly brightened, its magnitude being found to be about 7.7. On October 10, it had further brightened to about 7^M.6, where it remained until the observations terminated on November 22.

I find in looking up the star, that, although it is not included in any Catalogue of known variables accessible to me, it is in BIRMINGHAM's Catalogue of Red Stars, where it is numbered 483, and in the notes marked as a suspected variable, thus "Variable(?)"

Although the observations are insufficient to give us any definite facts regarding its period, range, etc., its redness (about 7 of CHANDLER's scale) would suggest a period of moderate length if regular, with a range of at least half a magnitude.

Brighton, Mass., 1893 *Feb.* 13.

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* Nearly ready for publication.

NOTE ON SAWYER'S NEW VARIABLE IN *AQUILA*.

By PAUL S. YENDELL.

I began a watch on this star, 1892 Sept. 21, and kept it under careful observation until Nov. 19, when it was too far west for further useful work. My observations, nineteen in number, show an increase from 8^M.0 at the first date, to 7^M.3 at the last, using SAWYER's scale, and seem to place the star's variability beyond question.

Dorchester, Mass., 1893 *Feb.* 14.

OBSERVATIONS OF COMETS,

MADE AT THE BOSTON UNIVERSITY OBSERVATORY WITH 7-INCH REFRACTOR,

BY J. B. COIT.

1892-3 Washington M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
COMET *d* 1892 (BROOKS).								
h m s			m s	′ ″	h m s	° ′ ″		
Dec. 5 16 30 35	1	8	+1 39.67	. . .	11 56 39.52	. . .	. . .	. . .
16 30 35	2	8 , 6	+1 26.81	+7 14.4	11 56 39.44	—21 6 58.2	*n*9.368	0.879
17 36 14	1	7	+1 54.33	. . .	11 56 54.18	. . .	. . .	. . .
17 36 14	2	7 , 6	+1 41.30	+4 34.3	11 56 53.93	—21 9 38.3	*n*9.038	0.894
COMET *f* 1892 (HOLMES).								
Nov. 11 6 59 44	3	13 , 6	+0 44.34	—2 50.1	0 44 53.56	+38 6 36.2	*n*9.426	0.108
17* 6 36 0	4	7	—0 51.90	. . .	0 42 49.26	. . .	*n*9.416	. . .
1893 Jan. 21† 8 19 20	5	7 , 3	—1 25.03	+3 44.7	1 28 39.26	+33 39 17.3	9.606	0.418
25 8 11 13	6	8	—0 2.36	. . .	1 34 13.30	. . .	9.609	. . .

Mean Places for 1892.0 and 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	11 54 58.13	+1.72	—21 16 41.3	— 5.2	Cincinnati Zone (1885) no. 2132
2	11 55 10.91	+1.72	—21 14 7.4	— 5.2	Cincinnati Zone (1855) no. 2133
3	0 44 6.24	+2.98	+38 9 0.1	+26.2	Weisse's Bessel 1083
4	0 43 38.26	+2.90	+37 36 57.0	+26.7	Paris 1020
5	1 30 5.15	—0.86	+33 35 24.3	+ 8.3	Weisse's Bessel 615
6	1 34 16.57	—0.91	+33 47 57.1	+ 8.2	⅓(2 Weisse's Bessel 726 + Lalande 3042)

* Observations were upon the most dense portion, which lay in the preceding part of the elliptical body. Three faint stars were seen through the comet, one very near the most dense point. The elliptical body was defective upon the n.f. quadrant.

† Bright stellar nucleus. On Jan. 25 comet was faint, but distinct, with moon at first quarter.

OBSERVATIONS OF COMET *g* 1892,

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

1893 Cincinnati M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Feb. 3 6 47 4	1	9 , 9	+0 15.97	—1 38.0	23 59 25.03	+33 38 36.9	9.661	0.400
6 47 4	2	5 , 5	—0 32.72	+7 57.3	23 59 24.99	+33 38 32.0	9.661	0.400
7 7 51 25	3	12 , 12	+0 59.23	+2 47.6	0 8 2.51	+31 3 16.0	9.712	0.579
11 6 58 4	4	10 . 10	—2 1.73	+3 59.0	0 15 9.97	+28 55 39.3	9.669	0.526
13 7 3 41	5	8 . 8	—2 40.80	+5 21.0	0 18 23.77	+27 58 46.6	9.674	0.553

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	23 59 10.65	—1.59	+33 40 13.0	+1.9	Brux. 10780, Leyden A.G.Z
2	23 59 59.29	—1.58	+33 30 32.7	+2.0	Leyden A.G.Z.
3	0 7 4.83	—1.55	+31 0 27.4	+1.0	Leyden A G.Z.
4	0 17 13.18	—1.48	+28 51 39.8	+0.5	Brux. 111, Arm. 2, 45
5	0 21 6.02	—1.45	+27 53 25.3	+0.3	Königsberg, A.N. 694

Feb. 11. Hazy. Comet faint.

Ephemeris of Comet *g* 1892.

Gr. M.T 1893	App. α	App. δ	log *r*	log Δ	Br.
	h m s	° ′			
Mar. 4.5	0 41 39	+21 48.8	0.1712	0.3332	0.60
6.5	43 37	21 22.1			
8.5	45 32	20 57.0	0.1816	0.3520	0.53
10.5	47 24	20 33.3			
12.5	0 49 13	+20 11.0	0.1920	0.3692	0.47
Mar. 14.5	0 50 58	+19 49.9			
16.5	52 42	19 30.0	0.2025	0.3818	0.42
18.5	51 24	19 11.1			
20.5	0 56 3	+18 53.2	0.2130	0.3989	0.37

FILAR-MICROMETER OBSERVATIONS OF COMET *f* 1892 (*HOLMES*),

MADE WITH THE 18½-INCH EQUATORIAL OF THE DEARBORN OBSERVATORY, NORTHWESTERN UNIVERSITY,

By G. W. HOUGH, Director.

1892-93 Evanston M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log *p*Δ for α	log *p*Δ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Nov. 21 7 10 30	1	4 , 4	−0 6.65.	+1 9.9	0 42 8.26	+37 3 51.8	*n*9.303	0 006
23 7 9 0	2	3 , 3	+0 18.33	−1 26.1	0 42 1.30	+36 51 3.2	*n*9.269	0.003
24 6 38 0	3	3 , 1	+0 35.93	+3 29.8	0 42 1.96	+36 45 6.0	*n*9.389	0.083
Dec. 19 8 13 43	4	12 , 12	+0 9.90	−1 5.3	0 52 27.01	+34 33 49.9	9.270	0.134
Jan. 9 7 6 37	5	3 , 3	−4 16.57	+2 35.7	1 13 15.73	+33 43 40.7	9.215	0.156
14 7 12 33	5	8	+1 52.87	. . .	1 19 25.11	. . .	9.314	. .
7 42 0	5	3	. . .	−1 16.4	. . .	+33 39 48.2	. . .	0.246
16 8 5 22	5	4	+4 29.40	. . .	1 22 1.62	. . .	9.507	. .
8 19 18	5	2	. . .	−2 0.4	. . .	+33 39 4.2	. . .	0.335
18 7 42 17	6	8	−0 9.61	. . .	1 24 37 71	. . .	9.471	. .
7 47 0	6	5	. . .	+1 29.6	. . .	+33 38 56 5	. . .	0.277
19 6 36 11	6	4 , 3	+1 6.79	+1 30.1	1 25 54.09	+33 38 56.9	9.192	0.167
23 6 32 0	7	3	+1 16.62	. . .	1 31 20.69	. . .	9.233	. .
6 40 36	7	3	. . .	+4 32.1	. . .	+33 40 1.8	. . .	0.179
26 7 13 53	8	3	+1 20.33	. . .	1 35 36 21	. . .	9.435	. .
7 24 0	8	3	. . .	−6 10.7	. . .	+33 41 52.5	. . .	0.271
30 7 7 35	9	9 , 6	+0 16.08	−1 15.2	1 41 22.82	+33 45 10.5	9.447	0.256

Mean Places for 1892.0 and 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 42 12.04	+2.87	+37 2 14.7	+27.2	*9ᴹ compared with Weisse's Bessel O. 1029
2	0 41 40.12	+2.85	+36 52 1.9	+27.4	†8ᴹ.5 compared with Paris 930
3	0 41 23.20	+2.84	+36 41 8.8	+27.4	Lund A.G. (11 obs.)
4	0 52 14.47	+2.64	+34 34 27.1	+28.1	Leyden A.G. (21 ")
5	1 17 33.08	−0.78 −0.86	+33 40 56.1	+8.6 +8.2	Leyden A.G. (21 ")
6	1 24 48.16	−0.84 −0.86	+33 37 18.5	+8.4 +8.3	Leyden A.G. (21 ")
7	1 30 4.98	−0.91	+33 35 21.6	+ 8.1	Leyden A.G. (21 ")
8	1 34 16.80	−0.92	+33 47 55.1	+ 8.1	Leyden A.G. (21 ")
9	1 41 7.65	−0.91	+33 46 47.5	+ 8.2	Leyden A.G. (21 ")

* Δα = +24ˢ.40, Δδ = −13″.5. † Δα = +2ᵐ 22ˢ.00, Δδ = +4′ 31″.6.

REMARKS.

This comet has exhibited such abnormal fluctuations in its volume and visibility, since its discovery, as to merit a careful study of its motion and physical condition.

During the month of November the comet was easily observed, although the nucleus had very little condensation at the center. In December the volume had greatly increased and it had become very much fainter, with no definite center of condensation.

On January 9, it appeared in the 18½-in. refractor, power 190, as a faint nebula about 2″ of arc in diameter with slight condensation. It presented a similar appearance on January 14

On January 16, however, a most remarkable change was observed in its appearance; instead of a faint diffuse nebula, there was seen a neat nebulous star of the 8.5 magnitude, with a coma of about 10″ of arc in diameter. The transformation, therefore, from a faint diffuse nebula to a nebulous star, must have taken place between the 14th and 16th January.

The star-like appearance, however, was of short duration, as the following measures will show:

Date.	Diameter of Nucleus.	Diam. of Envelope.
		″
Jan. 16.	8M.5 star	10 estimate
" 18.	7″	71
" 19.	4	76
" 23.	12	100
" 26.	33	Moonlight
" 30.	50	"

These measures depend on a single setting of the micrometer thread, but they show very clearly the increase in the volume of the comet from night to night.

The position on December 19th was determined by observing transits over an occulting bar, set successively at position-angles 0° and 45°, and recording the times with the printing chronograph. This method is not susceptible of any very great degree of precision, for difference of declination, when there is no definite point for observation, but I think it is preferable to the ring-micrometer under similar circumstances.

For determining difference of declination, however, the direct method is best, even if the object is so faint and diffuse as not to allow a steady illumination of the micrometer wires. One can do fairly good work by simply flashing the light on the wires for an instant. In case a small electric lamp is used for illumination, this object is readily accomplished by simply pressing a key.

During the period, January 16th to 26th, the physical condition of the comet was most favorable for the determination of position.

The observations are corrected for differential refraction. The approximate Longitude of the observatory is $+5^h\,50^m\,42^s.3 \pm 0^s.5$ Latitude $+42°\,3'\,33''.4$.

ON THE NEW VARIABLE IN *CYGNUS*.

$21^h\,37^m\,17^s.9$; $+37°\,21'.2$ (1855.0).

BY EDWIN F. SAWYER.

At the request of Mr. YENDELL, I undertook last year (1892), the observation of this star for the purpose of confirming its supposed variability. The star was first observed on July 23, and found to be 5 steps < DM. 37°4404, and 3 steps > DM. 37°4405 or 7M.9. Frequent observations were made from this date, but no positive evidence of change manifested itself until September 1.

On November 6, the star was observed to have taken a sudden and unmistakable drop, and was 2 steps < DM. 37°4405 or 8M.4. It continued to fade, and on December 9 was 5 steps < DM. 37°4405, and 4 steps > DM. 37°4400 or 8M.8. The magnitude-values were deduced from Mr. YENDELL's scale which agrees substantially with mine. The redness of the star appears about 8 of Dr. CHANDLER's scale.

Brighton, 1893 *Feb.* 27.

NEW ASTEROIDS.

Professors KRUEGER and KREUTZ have communicated the discovery of two more small planets.

1893 *F*. WOLF, Jan. 16. 13M.

	h m	h m s	° ′ ″
Jan. 16	10 30 Greenw. M.T.	α = 9 22.1	δ = +19 50
	12 47	9 22 4.25	+19 49 45.5
23	11 54	9 15 52.03	+20 42 57.2

1893 *G*. CHARLOIS, Jan. 21. $11\frac{1}{2}$M

Jan. 22 $16^h\,42^m.0$ Nice M.T. $\alpha = 9^h\,31^m\,33^s.3$ $\delta = +25°\,13'\,22''$

Found independently by WOLF,

Feb. 5 $9^h\,12^m.3$ Heidelberg M.T. $\alpha = 9^h\,16^m\,52^s$ $\delta = +25°\,37'$

Another, subsequently found, proved to have been already on record; and, to avoid confusion, the letter *H* will be omitted from the series of 1893, and the asteroid next discovered designated as *J*.

1893 *J*. CHARLOIS, Feb. 11. $12\frac{1}{2}$M.

Feb. 15 $7^h\,17^m.5$ Nice M.T. $\alpha = 10^h\,19^m\,28^s$ $\delta = +15°\,2'$.

Daily motion -44^s in α, and 9′ northward.

Dr. WOLF has assigned the following names to small planets found by him:

No. 328	1892 March 18	*Gudrun*	No. 333 = 1892 *A*	1892 Aug. 22	*Badenia*
332	" 19	*Siri*	339 = *G*	Sept. 25	*Dorothea*

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OBSERVATIONS OF VARIABLE STARS AT THE OBSERVATORY OF UPSALA,

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II.

The following observations form the continuation and conclusion of the series published in no. 254 of the *Astronomical Journal*, and, with the exception of those on *β Persei* and *λ Tauri*, were made with the same instrument as the former.

In the winter of 1891–92 the observations were unfortunately interrupted. On Nov. 8, I contracted a severe cold, which would have prevented me from observing, even if this had otherwise been possible. But an interval of cloudy weather set in at the same time, and lasted until Dec. 4. Even after this date, I found a certain amount of prudent care imperative, so that I was compelled to restrict my activity in observing, to a greater extent than would otherwise have been the case. The long cloudy period affected more or less prejudicially the accuracy of some of the epochs.

Toward the end of August, Dr. CHARLIER expressed a desire to employ the same telescope for some other observations; and since notice was received at the same time that the new large refractor was nearly completed, and under the conditions of our weather it is not easily possible that two observers should use the same instrument for different purposes, without interference, I decided to abandon observations with the 6-inch telescope. Consequently, I took only a few additional observations for completing a couple of series, the last of these on Sept. 12.

1. 107 *T Cassiopeae.*

This star was observed on 46 evenings, from 1891 Aug. 7 to 1892 Apr. 28. Up to Nov. 7, the brightness increased quite slowly and somewhat irregularly, and then began the above mentioned long interruption. During this interval a rapid and decided increase in brightness had occurred, which lasted for 17 days more: so that the star obtained its maximum as follows.

Max. = 1891 Dec. 21; Mag. = $7^{M}.6$

The brightness now rapidly decreased until Jan. 27, after which followed a stationary interval of a month. Then came a rapid, although not always regular, decrease, until the star became $10^{M}.2$ at the end of April. From July 24 to Aug. 22, 7 observations show a slow increase from $10^{M}.2$ to $9^{M}.7$. The epoch of maximum, as above given, appears to be quite accurate.

SCHÖNFELD gives the period as 436 days; the combination of SCHÖNFELD's and CHANDLER's normal epochs gives 441^{d}, and the latter combined with mine gives 448^{d}. An increase in the period therefore appears probable.

2. 112 *R Andromedae.*

Thirty-four observations were obtained from 1891 Sept. 22 to 1892 Mar. 28, and although the interruption Nov. 8 to Dec. 4 has a somewhat disturbing influence, they give with much accuracy

Max. = 1891 Dec. 8: Mag. = $7^{M}.7$.

The increase was considerably more rapid than the decrease. Here too, there appears to be an increase in the period. SCHÖNFELD found 405 days, CHANDLER 411^{d}, and the combination of his epoch and mine gives 417^{d}.

3. 243 *U Cassiopeae.*

The star remained invisible in my telescope from 1891 Oct. 8 to 1892 Jan. 28, or rather, it was not observed during this time. Yet the light-curve shows that it might have been seen as early as Jan. 14. A very trustworthy determination from 18 observations, Jan. 28 to May 16, gives

Max. = 1892 Mar. 28: Mag. = $8^{M}.8$.

A combination of this epoch with Mr. TOWNLEY's observations (*A.J.* no. 249), gives the data

Epoch	Maximum	Mag.	O—C
			d
0	1889 Dec. 21	8.8	—2
1	1890 Sept. 27	8.0	+3
3	1892 Mar. 28	8.8	—1

whence we have

Max. = 1889 Dec. 23 + $275^{d}.4\,E$

The differences between observation and calculation are given in the column O—C.

4. 320 *U Cephei.*

I have been able to observe the following minima of this star:

Upsala M.T.	d	h	m	Obs.	Mag.	Remarks
1889 Nov.	28	12	39	12	–	good
Dec.	28	10	33	29	–	good
1890 Nov.	27	11	37	13	9.4	uncertain
1891 Jan.	6	9	12	21	9.4	good
1892 Apr.	21	12	37	14	9.5	good
May	16	11	22	8	9.5	uncertain

The first minimum was observed experimentally with a Zöllner's photometer. The observations for the third and the last minimum began later than was desirable.

5. 793 *T Persei.*

The observations began Aug. 9, and 41 observations were obtained up to 1892 May 5. The star increased from $8^M.6$, and attained the following maximum,

Max. = 1891 Sept. 22; Mag. = $8^M.1$

The brightness then diminished, at first with moderate rapidity, then with extreme slowness. A minimum, of $8^M.9$, is indicated during the first few days of February. In June the star had become somewhat brighter, but in July and August was again faint.

6. 811 *S Persei.*

From 1891 Aug. 9 to 1892 Aug. 22, 57 observations were obtained. They allow a secondary minimum and a maximum to be moderately well determined. I find,

Min. = 1891 Nov. 12; Mag. = $8^M.3$
Max. = 1892 Mar. 10; = 7.8

Until about the end of May the variations were very insignificant. But from that time on, there was a slow but decided decrease, and on Aug. 22 the star had fallen to $9^M.0$, or even somewhat fainter. The observations of Mr. Schwarzschild, published in *A.N.* 3096, confirm the faintness of its light in November, as well as the increase in February.

7. 1090 *β Persei.*

I have been able to determine the following 7 minima:

Upsala M.T.	d	h	m	Mag.	Obs.	Remarks
1890 Dec.	16	9	15	3.6	27	very good
1891 Aug.	31	10	50	3.5	15	good
Sept.	23	9	40	3.6	13	moderately good
Oct.	16	7	51	3.6	10	moderately good
Nov.	2	12	55	3.5	19	very good
Nov.	8	6	27	3.5	11	somewhat uncertain
Dec.	21	6	32	3.4	12	moderately good

8. 1222 *R Persei.*

This star was observed 22 times, 1891 Aug. 4–Nov. 7, and 14 times, 1892 Jan. 28–Apr. 25. From these we deduce

Max. = 1891 Aug. 30; Mag. = $8^M.5$
Max. = 1892 Apr. 2; = 8.8

Both epochs are very well determined.

9. 1411 *λ Tauri.*

Nineteen observations give, with tolerable certainty,

Min. = 1891 Nov. 2 13^h 13^m Upsala M.T; Mag. = $4^M.4$

10. 1623 *T Camelopardalis.*

I began to search for this new variable Aug. 15, but could not recognize it, either on this date or on Aug. 17 and 29. But on Sept. 8 I found it $9^M.5$. Only three days later it was $9^M.0$, and on Sept. 19, $8^M.4$. From this point to the end of January 1892, the variations were but small; but during this interval a secondary minimum was indicated. Unfortunately the interruption from Nov. 7 to Dec. 4 prevented an absolutely certain decision regarding the existence of this inflection. I assume provisionally,

First maximum = 1891 Oct. 13; Mag. = $8^M.1$
Secondary minimum = Nov. 12; = 8.5
Principal maximum = Dec. 24; = 7.9

In February, March and April, the brightness diminished with increasing rapidity, and on May 5 it was $11^M.5$, and in the very bright nights was almost at the limit of visibility for my telescope. During the last half of July I sought for the star several times without success, and not until Aug. 5 and 10 could I first suspect a trace of its appearance. On Aug. 14 it was clearly visible, and at the last observation, Sept. 12, it was $9^M.6$. The period of the star is therefore somewhat more than a year, and at minimum its magnitude is certainly below 12^M.

11. 1855 *R Aurigae.*

Forty observations were obtained, from 1891 Aug. 15 to 1892 Apr. 28, inclusive. The variations were rapid, especially so the increase. During the decrease there were stationary periods, particularly in March and December. I obtain,

Max. = 1891 Nov. 8; Mag. = $7^M.0$

The accuracy of the epoch is somewhat diminished by the influence of the cloudy period in November.

12. 1923 *S Aurigae.*

I observed this star 11 times from 1890 Oct. 7 to 1891 Jan. 9, and also 1891 March 27, without recognizing its variability as certain, and then 32 times, from 1891 Aug. 9 to 1892 Apr. 20. It was already bright at the time of the first observation. A maximum of $9^M.3$ appears to have occurred on Sept. 12, and a very uncertain minimum of $11^M.2$ on March 31.

13. 1953 *T Aurigae* (*Nova*, 1892).

The following estimates of the magnitude of this star were made by Argelander's method.

	M		M
1892 Feb. 2	5.4	Mar. 17	8.5
3	5.0	19	8.9
4	5.1	20	9.2
9	5.5	22	9.8
16	6.2	25	11.0
21	6.0	27	11.2
24	6.2	28	11.4
25	5.8	29	11.5
Mar. 2	5.6	30	12.0

Prof. PICKERING gives the brightness of the star on Mar. 29 as 13^{M}.0,—a magnitude which in a telescope like mine is always invisible.

14. 2100 *U Orionis.*

I have observed this star 16 times during the winter of 1890–91, from Oct. 23 to Jan. 10, and also on Mar. 27. In the autumn and winter of 1891–92 I obtained 37 observations, from Aug. 17 to May 1. From these I obtain the following data:

Max. = 1891 Jan. 27; Mag. = 6^{M}.5 quite uncertain
Min. = Sept. 4; = 11.3 very uncertain
Max. = 1892 Feb. 7; = 6.0 good

15. 2178 *R Lyncis.*

From 1892 Feb. 24 to July 29, 21 observations were made. In consequence of the bright nights and the low position of star, none could be obtained in June, and from July 1 to 12 I was absent. The deduced maximum,

Max. = 1892 May 30; Mag. = 7^{M}.2

is therefore uncertain by a few days.

16. 2815 *U Geminorum.*

Besides the maxima published in No. 254 of this Journal, I have observed the two following:

Third Maximum. After nine days of cloudy weather, I found *U* bright 1892 Jan. 28, and obtained the following estimates of its brightness:

1892 Jan. 28	27.1
29	27.1
31	24.3
Feb. 2	11.0
3	5.1

From these observations, by themselves, nothing could be inferred, except that a maximum occurred on Jan. 29 at latest, perhaps indeed several days before Jan. 28, but not earlier than Jan. 18. Messrs. KNOTT and YENDELL, however, have communicated observations, in *A.N.* 3099 and *A.J.* 256, which make it possible to draw nearer inferences as to the time of maximum, and the beginning of the variation; and the more so since it appears that Mr. KNOTT has at his disposal unpublished observations of Messrs. BAXENDELL and MITCHELL, made previously to his own. Mr. KNOTT puts the maximum on Jan. 24, and the beginning of the variation on Jan. 22.

Fourth Maximum. For this maximum I have been able to fix very sharply the beginning of the variation. On Mar. 29 I found, in an extraordinarily clear atmosphere, WINNECKE's comparison-star *a* distinctly visible, while *U* was not certainly visible. On Mar. 30, *U* was visible, but very faint. I found,

9^{h} 25^{m} *d* 6 *U* 1 *b* : hence *U* = 1.

On April 3, *U* was 19.1, and on Apr. 7 it was invisible, while *b* was occasionally "glimpsed."

It thus appears completely certain that the increase began on the afternoon of Mar 30, and that on Apr. 7 *U* had fallen to its usual brightness. From analogy with the appearance in October 1891, the maximum can be fixed on Mar. 31. Mr. KNOTT finds, on the contrary, maximum = Apr. 1.

The maxima observed this winter are consequently,

1891 Nov. 1
1892 Jan. 24 Interval 84 days
Apr. 1 Interval 68 days

Combining with these the maximum 1891 Jan. 8, we have, as a mean from the four maxima, a period of 74^{d}.8, with the residual errors: —1^{d}, —3^{d}, +6^{d}, —1^{d}; which are somewhat too large. Mr. CHANDLER, however, finds the mean period to be 86 days: thus affording another proof of the irregularity of the light-variation.

The observations indicate, moreover, how desirable it would be could the observations of several astronomers be combined for determining the epochs of maximum. To this end, the observations would need to be published in a way different from what has been usual. Data assigning the magnitudes cannot be employed by other astronomers. Mr. KNOTT, for example, gives the magnitude as 13^{M}.3 on Mar. 30. I saw the star on that day without any difficulty, and estimated it as about 11^{M}.7. Nor can estimates by ARGELANDER's method be employed without some other information; for at least two different systems of comparison-stars are employed, namely, WINNECKE's (*A.N.* 1120), and that of KNOTT. A comparison of these systems is much to be desired. Yet I cannot do this, since I do not know where KNOTT has published his system of comparison-stars.

17. 3109 *S Cancri.*

In spite of all my efforts, I have been unable to obtain more than one minimum of this interesting star. This minimum depends on 16 observations, which include an interval of 9.6 hours. It is,

Min. = 1892 Feb. 25^{d} 13^{h} 12^{m} Upsala M.T.; Mag. = 9^{M}.4

The peculiar form of the light-curve, with an increase of only 2–3 steps during the three hours after minimum, affects considerably the accuracy of the determination.

18. 3825 *R Ursae Majoris.*

The actual observations of this star began considerably later than I intended. In order to determine the minimum, I observed indeed, during the period from August to December, a star which I supposed to be *R*, but in order to be free from prepossession, I made no reduction of the observations. On 1892 Jan. 4 I perceived, however, that another star of 9^{M}.8, not previously observed, must be the true *R Ursae*. Since this time, up to May 10, inclusive, I have obtained 16 observations, and find, quite certainly,

Max. = 1892 Feb. 16; Mag. = 6^{M}.8

19. 4511 *T Ursae Majoris.*

Forty-five observations were made from 1891 Aug. 9 to

1892 Apr. 28, and 9 from July 24 to Aug 16. These observations give, with very great precision,

Max. = 1891 Oct. 30; Mag. = $8^{\mathrm{M}}.0$
Min. = 1892 Mar. 22; = 11.0

The minimum magnitude appears to me to be given decidedly too bright, by reason of the step-value below $9^{\mathrm{M}}.5$ having been different from that above it. I assume that the star was not brighter than $11^{\mathrm{M}}.5$. The accuracy of the minimum epoch will not thereby be affected.

The observations in July and August began only somewhat after the epoch of maximum, and do not suffice to determine it. They are, however, of interest, as showing that this maximum was very much brighter than the preceding one. The star increased to at least $7^{\mathrm{M}}.1$.

20. 4557 *S Ursae Majoris.*

I obtained from 1890 Oct. 24 to 1891 Jan. 9, 14, and from 1891 Aug. 9 to 1892 Apr. 28, 47 observations; and obtain from them the following epochs:

Max. = 1890 Nov. 24; Mag. = $7^{\mathrm{M}}.7$
Min. = 1891 Nov. 11; = 10.8
Max. = 1892 Feb. 22; = 7.7

All these epochs are tolerably good, although not very accurate.

21. 4948 *R Canum Venaticorum.*

This newly discovered and apparently little observed variable, I have observed 15 times between 1890 Oct. 15 and 1891 Jan. 9; once on 1891 Apr. 5, and 56 times between 1891 Aug. 7 and 1892 May 5. Thence I deduce

Max. = 1891 Jan. 2; Mag. = $7^{\mathrm{M}}.0$
Max. = Dec. 6; = 6.7

On 1892 May 5 the star had sunk to $10^{\mathrm{M}}.8$, and was still decreasing. The second maximum is well determined, even if perhaps somewhat affected by the interruption between Nov. 7 and Dec. 4. But the first maximum is quite uncertain, since the single observation, 1891 Apr. 5, was made long after the maximum had passed. The two maxima give the following provisional elements:

Max. = 1891 Dec. 6 $+ 338^{\mathrm{d}} E$

The brightness at minimum appears to lie almost certainly between 11^{M} and 12^{M}. A minimum cannot be determined here before 1894, inasmuch as observations of faint stars are not possible in May.

22. 5157 *S Bootis.*

Fourteen observations fall between 1890 Oct. 15 and 1891 Jan. 9: 1 on 1891 Apr. 5, and 42 between 1891 Aug. 4 and 1892 Apr. 28. From these we have

Min. = 1891 Feb. 18; Mag. = $11^{\mathrm{M}}.7$
Min. = Nov. 8; = 11.5
Max. = 1892 Mar. 23; = 8.6

I believe that here also the minimum magnitudes are too bright. In November, 1891, when just at minimum, the star, while it did not cease to be visible, was even under favorable circumstances a *minimum visibile* for a telescope of 162mm, hence about $12^{\mathrm{M}}.0$. The first minimum-epoch is naturally quite uncertain; the second is better, but the large gaps in the observations after Nov. 7 make it still somewhat uncertain. Around the maximum the observations do not agree well; yet this epoch is moderately certain. If we combine it with CHANDLER's epoch of maximum in *A.J.* 179, we have,

Period = $269^{\mathrm{d}}.06$

On the other hand my minimum-epoch, Nov. 8, combined with CHANDLER's gives,

Period = $269^{\mathrm{d}}.70$

In both cases, therefore, a not unmarked shortening is distinctly required.

23. 5194 *V Bootis.*

Thirteen observations, 1890 Nov. 20 – 1891 Jan. 9, and an isolated one on Mar. 29, give, with moderate uncertainty,

Ep. 9 Max. = 1890 Dec. 17; Mag. = $6^{\mathrm{M}}.9$

Eighty-one observations, 1891 Aug. 7 – 1892 Aug. 20, give,

Ep. 10 Max. = 1891 Aug. 27; Mag. = $7^{\mathrm{M}}.1$
10 Min. = 1892 Feb. 13; = 9.2
11 Max. = May 27; = 7.1

Both these maxima are quite accurate, but the minimum is very uncertain on account of the sparsity of the observations Jan. 6 – Mar. 17.

The deduction of a formula is difficult, owing to the uncertainty of most of the observations. I have therefore abandoned all attempts to obtain one which shall represent not only the actual observations but also the previous estimates, and have deduced the following only from the Epoch 0 and the last three.

Max. = 1884 Aug. 30 $+ 256^{\mathrm{d}} E$
Min. = 1885 Feb. 5 $+ 256\ E$

The observations are represented as follows:

MAXIMA		MINIMA	
E	O—C	E	O—C
0	0^{d}	0	-8^{d}
1	+19	1	+4
2	+25	10	+4
3	+26		
9	−4		
10	−7		
11	+11		

24. 5190 *R Camelopardalis.*

Sixty-one observations, from 1891 Aug. 9 to 1892 Aug. 14, give,

Max. = 1891 Oct. 26; Mag. = $7^{\mathrm{M}}.2$
Min. = 1892 Apr. 9; = 11.4
Max. = July 18; = 7.5

The variations proceeded quite regularly, and the increase was somewhat more rapid than the decrease. All the epochs are very well determined. At minimum the star was nearly at the limit of visibility in my telescope. I estimate the actual minimum brightness as about $11^{M}.8$.

25. 5484 *U Coronae*.

The following minima were observed:

Upsala M.T.		d	h	m	Mag.	Obs.	
1891	Apr.	12	12	6	9.0	20	very good
	Apr.	19	10	8	9.0	18	good
	Sept.	11	9	27	8.9	14	moderately good
	Oct.	26	7	1	9.0	6	very uncertain
1892	July	28	10	42	9.0	11	very uncertain

26. 5504 *S Coronae*.

Eighteen observations from 1892 Feb. 24 to June 4 give, very certainly,

Max. = 1892 Mar. 23 ; Mag. = $6^{M}.9$

The rise to maximum was very regular, but irregularities occur in the descending curve. Besides these observations, I have 25 others, made for the purpose of determining the minimum. But towards the end of the series, they were so interrupted that no trustworthy result can be deduced.

27. 5675 *V Coronae*.

Ten observations, from 1890 Nov. 20 to 1891 Jan. 9, and one on Mar. 27 give very uncertainly,

Min. = 1890 Dec. 22 ; Mag. = $10^{M}.9$

Sixty-nine observations, from 1891 Aug. 7 to 1892 Aug. 22, give

Min. = 1892 Jan. 4 ; Mag. = $11^{M}.3$
Max. = June 5 ; Mag. = 7.6

We might assuredly obtain a somewhat better agreement with the observations by assuming two maxima, a principal maximum on May 20, and a somewhat fainter secondary one on June 30, with a secondary minimum on June 17. But since such an irregularity has not previously appeared, I have adhered to the above dates. I find the following formula for the maxima, which is identical with one found by me in 1885, except for the correction of -1^{d} for the principal epoch.

$$\text{Max.} = 1878\ \text{Oct.}\ 24.5 \quad +355^{d}.38\,E$$

From the four minima previously observed by me I have deduced the following formula:

$$\text{Minima} = 1879\ \text{May}\ 2 \quad +355^{d}.38\,E$$

The observed maxima and minima, as well as all the other data known to me with regard to the brightness of the star, are represented by these formulas, as the following tables show.

MAXIMA AND BRIGHT ESTIMATES.

Ep.	Computed Max.	Observations	
—22	1857 May 29	1857 Apr. 18, $8^{M}.5$	(BONN DM.)
—20	1859 May 10	1859 July 25, >8.0	(WINNECKE)
—19	1860 Apr. 30	1860 April >8.0	(WINNECKE)
—18	1861 Apr. 20	1861 Mar. 19, >8.0	(WINNECKE)
0	1878 Oct. 24.5	Max. 1878 Oct. 20	(DUNÉR)
+ 1	1879 Oct. 14.9	Max. 1879 Oct. 12	(SCHMIDT)
		Oct. 13	(DUNÉR)
+ 2	1880 Oct. 4.3	Max. 1880 Oct. 3	(DUNÉR)
+ 3	1881 Sept. 24.6	Max. 1881 Oct. 3	(SCHMIDT)
+ 4	1882 Sept. 15.0	Max. 1882 Sept. 15.6	(SCHMIDT)
+ 5	1883 Sept. 5.4	Max. 1883 Sept. 5	(SCHMIDT)
+ 6	1884 Aug. 25.8	Max. 1884 Aug. 31	(DUNÉR)
+14	1892 June 7.9	Max. 1892 June 5	(DUNÉR)

MINIMA AND FAINT ESTIMATES.

Ep.	Computed Min.	Observations	
—10	1869 Aug. 8	Ft.* 1869 July 4,	(TIELE)
— 6	1873 June 29	Inv. 1873 Mar. 14,19	(BIRMINGHAM)
		" Apr. 20	(BIRMINGHAM)
— 5	1874 June 20	" 1874 Apr. 10	(BIRMINGHAM)
— 2	1876 May 31	" 1876 Aug. 1	(BALL)
— 1	1877 May 21	" 1877 May 11	(SEELIGER)
0	1879 May 2.0	Min. 1879 May 1	(DUNÉR)
+ 1	1880 Apr. 21.4	Min. 1880 Apr. 25	(DUNÉR)
+12	1890 Jan. 3.6	Min. 1890 Dec. 22	(DUNÉR)
+13	1891 Dec. 25.0	Min. 1892 Jan. 4	(DUNÉR)

* "*kaum zu sehen.*"

28. 5950 *W Herculis*.

This star was observed 9 times from 1890 Nov. 16 to 1891 Jan. 9; once on Mar. 29; and 49 times from 1891 Aug. 7 to 1892 Aug. 22. Thence we have

Max. = 1891 Jan. 11 ;	Mag. =	$8^{M}.3$	uncertain
Max. = Oct. 8 ;	=	8.2	good
Min. = 1892 Mar. 7 ;	=	11.0	somewhat uncertain
Max. = July 10 ;	=	7.9	very good

From earlier dates we have the estimates of magnitude in the Bonn *Durchmusterung*.

1857 Apr. 17 ; Mag. = $8^{M}.5$
May 15 ; = 9.0

By means of the light-curve I thence assume.

Max. = 1857 March 24

Since the confirmation of the variability of the star, I have determined the following epochs:

Ep.			
0	Min. =	1880 Sept. 26	somewhat uncertain
0	Max. =	1881 Jan. 24	very uncertain
6	Min. =	1885 May 13	" "
6	Max. =	Sept. 5	" "
7	Max. =	1886 July 1	moderately good

From the aggregate data I obtain the formulas,

$$\text{Max.} = 1881\ \text{Feb.}\ 17.1 \quad +278^{d}.85\,E - 0^{d}.091\,E^2$$
$$\text{Min.} = 1880\ \text{Oct.}\ 1 \quad +278.85\,E - 0.091\,E^2$$

The comparison of these formulas with the observations gives for the residual errors,

Maxima Ep.	Maxima O—C	Minima Ep.	Minima O—C
—31	$+2^{\mathrm{d}}$	0	-5^{d}
0	—24	6	+15
+ 6	— 9	15	—11
+ 7	+12		
+13	+ 5		
+14	— 1		
+15	— 1		

These errors are not larger than we should expect, from the uncertainty of several of the epochs.

29. 5948 *R Ursae minoris.*

Twelve observations, between 1890 Oct. 15 and 1891 Jan. 9, and 36 between 1891 Aug. 7 and 1892 May 10, give the following epochs:

Min. = 1890 Nov. 21 ; Mag. = $9^{\mathrm{M}}.5$
Min. = 1891 Oct. 28 ; = 9.9
Max. = 1892 Feb. 7 ; = 8.6
Min. = Mar. 31 ; = 9.2

All these epochs, especially the last two, are uncertain, for the observations agree badly. The three minima give the period 166 days, with the residual errors -2^{d}, $+7^{\mathrm{d}}$, -4^{d}. If we unite my minima, however, with Chandler's normal epoch, 1881 May 23, we find, according as we count the number of the epoch 1891 Oct. 28, as 23, 22, or 21. the following periods and residual errors:

$P = 165.3$ Ep.	O—C	$P = 173.0$ Ep.	O—C	$P = 181.4$ Ep.	O—C
0	0	0	0	0	0
21	—3	20	+ 9	19	+23
23	+7	22	+ 4	21	+ 1
24	—3	23	—14	22	—25

The last value does not appear consistent with my observations.

30. 5955 *R Draconis.*

Forty observations, between 1891 Aug. 4 and 1892 Apr. 28, give with considerable certainty:

Min. = 1891 Sept. 27 ; Mag. = $11^{\mathrm{M}}.5$
Max. = 1892 Jan. 13 ; = 6.9

Uniting the maximum-epoch with Chandler's principal epoch, we get

$$\text{Max.} = 1858 \text{ June } 5.0 \quad + 245^{\mathrm{d}}.5\, E$$

With Mr. Yendell's last observed maximum we get the period $245^{\mathrm{d}}.56$.

31. 6189 *U Ophiuchi.*

The conditions for observing this star at Upsala are highly unfavorable, since the nights are too bright and short at the time when it could otherwise best be followed. In consequence I have been able to observe only four minima with sufficient completeness to get moderately certain epochs. These are:

Upsala M.T.	Mag.	Obs.	
1890 Apr. $3^{\mathrm{d}}\ 14^{\mathrm{h}}\ 15^{\mathrm{m}}.5$	7.0	28	very good
1892 Apr. 21 12 47.6	7.0	13	good
July 24 11 30.6	7.0	13	quite good
July 29 11 55.0	7.1	9	rather uncertain

32. 6512 *T Herculis.*

I observed this star from 1891 Aug. 7 to 1892 Sept. 5, 63 times. The maxima in 1891 September and 1892 August are determined with great sharpness. On the contrary, the observations between Nov. 7 and Mar. 17 were far too sporadic to determine a second maximum independently. Nevertheless, with the aid of the light-curve found from the other observations, a tolerable epoch may be determined for it. I find:

Max. = 1891 Sept. 17 ; Mag. = $8^{\mathrm{M}}.2$
Max. = 1892 Feb. 29 ;
Max. = Aug. 3 ; = 7.5

If we correct the first and third maxima, by means of Chandler's sine-formula, by $-4^{\mathrm{d}}.83$ and $-5^{\mathrm{d}}.0$, and combine them with his principal epoch, we find the period $165^{\mathrm{d}}.02$.

33. 7045 *R Cygni.*

Fifteen observations were made from 1890 Oct. 15 to 1891 Jan. 10, and 34 from 1891 Oct. 24 to 1892 May 10. The invisibility of the star in my telescope was established on 21 days, from 1891 Aug. 7 to Oct. 12, inclusive. The observations give the following epochs:

Max. = 1890 Nov. 25 ; Mag. = $7^{\mathrm{M}}.4$
Max. = 1892 Feb. 17 ; = 7.0

The maxima were quite well determined, although the flatness of the light-curve near the time of maximum makes them somewhat uncertain.

34. 7120 *χ Cygni.*

The star was observed 40 times, from 1891 Aug. 7 to Nov. 7. I thence obtain

Max. = 1891 Aug. 21 ; Mag. = $4^{\mathrm{M}}.9$

During the whole interval the variations were very rapid and regular. While it would have been desirable for the observations to have begun earlier, yet the epoch appears to be very well determined.

35. 7192 *Z Cygni.*

As a continuation of the observations communicated in no. 254, I have made 22 observations between 1891 Nov. 7 and 1892 May 10. From these we have:

Min. = 1891 Dec. 6 ; Mag. = $11^{\mathrm{M}}.2$
Max. = 1892 Apr. 3 ; = 7.1

The minimum is uncertain, as there were no observations between Nov. 7 and Dec. 21. But the maximum is very well fixed. The maxima observed by me do not permit a sharp determination of the period; inasmuch as both of the earlier ones, particularly the second, are uncertain. Perhaps we may assume,

Max. = 1890 Nov. 2 $+259^{d}\,E$

which accurately represents the extreme maxima, but places the second on July 19, which is by no means irreconcilable with the observations. The minima appear to fall 139 days after the maxima; and the minimum brightness, judging from some observations in August 1892, is somewhat below $11^{M}.5$.

36. 7220 *S Cygni.*

After looking for the star on 19 days between 1891 Aug. 7 and Dec. 12, without certainly seeing it, it was finally distinctly recognized, on Dec. 21, as $11^{M}.0$, and observed on 16 days, until it had sunk almost to 12^{M} on Mar. 29, when I gave up further observation. I find quite certainly,

Max. = 1892 Feb. 4; Mag. = $9^{M}.5$

As no recent elements are known, and those of SCHÖNFELD are now so far out as to put the maximum on Dec. 24, when the star was scarcely brighter than 11^{M}, I have combined my epoch with SCHÖNFELD's principal one 1869 Jan. 20, and find the resulting elements:

Max. = 1869 Jan. 20 $+323^{d}.65\,E$.

37. 7259 *RS Cygni.*

The variability of this star was pointed out by Mr. ESPIN. I have observed it 51 times, from 1891 Aug. 4 to 1892 Aug. 22, and consider the variation certain, although the strong color of the star influences the accuracy of the observations, and perhaps leads to differences in the mode of estimation, even by one and the same observer. Thus, with respect to my own observations, it might appear suspicious that, although the star was called faint in 1891 from Aug. 4 to Nov. 7, it appeared very much brighter after the gap from Nov. 7 to Dec. 12; that, after an interruption of almost a month, from Feb. 25 to Mar. 19, some fainter estimations were made, and brighter ones again after a new gap, May 10–June 17. But it would be ascribing far too great an influence to these circumstances, did we attribute to them exclusively the fact that the star was estimated as fainter than DM. 39°3958 in 19 observations, from Sept. 9 to Nov. 7, while from Jan. 4 to July 29 it always appeared brighter than DM. 38°3956, and until July 17 almost always brighter than DM. 38°3946. Much less can the circumstance be thus explained, that during the interrupted observations of August–November 1892 the star decreased by fully a half-magnitude, and in July–August 1892 by actually a full magnitude. Consequently, by keeping strictly to the observations, I find

Min. = 1891 Oct. 16; Mag. = $\overset{M}{8.3}$
Max. = 1892 Apr. 26; = 6.8

The minimum is thus quite accurately determined. But on the other hand the star remained almost constant from the end of January to the middle of May, and even seemed to pass a secondary minimum of $7^{M}.0$ in March and April; yet I attribute this, provisionally, only to the above-mentioned circumstance. The epoch of maximum is, however, highly uncertain. As regards the period, it appears to be, if regular, about 380 days; for the star had almost the same brightness at the end, as at the beginning, of the observations.

38. 7299 *U Cygni.*

From 19 observations between 1891 Aug. 4 and 1892 May 10, I obtain

Max. = 1891 Sept. 7; Mag. = $\overset{M}{7.8}$
Min. = 1892 Apr. 22; = 9.9

The maximum is very well fixed, since the change of light in the immediate neighborhood of the maximum was tolerably rapid, although otherwise very slow. Some of the observations do not agree well, especially those made in the spring, at a low altitude; all which is to be ascribed to the intense color of the star.

39. 7194 *R Cephei.*

By 17 observations, between 1891 Aug. 15 and 1892 Apr. 28, a minimum of $8^{M}.4$ is indicated in the middle of January 1892. The observations from 1891 November to 1892 April were, however, too infrequent to permit a safe inference from them.

40. 7428 *V Cygni.*

From 1891 Aug. 7 to 1892 Apr. 28, 44 observations were made, giving,

Max. = 1891 Sept. 16; Mag. = $8^{M}.4$

The light-curve rises and falls regularly, although not rapidly, for 40 days before and 47 days after maximum. The brightness then remained constant for two months, decreasing rapidly afterwards. As there was an interruption for this star also, of more than a month after Nov. 7, it is probable that the secondary maximum mentioned by CHANDLER occurred in this interval. Combining my epoch with CHANDLER's principal epoch, we have the elements,

Max. = 1881 June 1 $+418^{d}\,E$.

41. 7437 *X Cygni.*

During the summer of 1892, I was able to determine two maxima and three minima, which are here given, together with their deviations from my elements in no. 254.

Maximum.	Mag.	Obs.	O—C
1892 July 25.4	6.3	6	+1.5
Aug. 9.4	6.2	3	+0.1
Minimum.	Mag.	Obs.	O—C
1892 July 18.4	7.6	6	0.0
Aug. 3.2	7.5	3	—0.6
Aug. 20.1	7 5	6	—0.1

These three minima were consequently all bright ones.

42. 7188 *Y Cygni.*

Besides the minima published in no. 265. I have observed the following:

Upsala M. T.				Obs.	
	d	h	m		
1892 Apr.	7	12	3	14	very good.
Apr.	25	11	26	9	somewhat uncertain.
Apr.	28	11	12	14	very good.
May	1	10	56	8	very uncertain.
May	10	10	45	11	quite good.

43. 7609 *T Cephei.*

Sixty-six observations. from 1891 Aug. 9 to 1892 Sept. 12. give,

Min. = 1892 Jan. 12 ; Mag. = $9^{M}.6$
Max. = Aug. 1 ; = 5.2

The epoch of minimum is quite well determined. although by no means to a degree commensurate with the large number of observations. For example, the 20 observations of August and September 1891 have no bearing on the minimum-epoch. The epoch of maximum is very well fixed, although the strong color of the variable and its large distance from the comparison-stars were unfavorable.

44. 7754 *W Cygni.*

This star was observed 16 times between 1890 Oct. 15 and 1891 Jan. 10. and 88 times between 1891 Aug. 7 and 1892 Sept. 12. The results are as follows:

Epoch			Mag.	O—C
				d
Min. =	1890	Nov. 8	6.6	+ 2.9
Max. =		Sept. 21	5.4	— 2.7
Min. =		Dec. 2	6.5	+ 1.0
Max. =	1892	Feb. 7	5.5	+ 6.0
Min. =		Mar. 29	6.1	—11.3
Max. =		June 11	5.0	+ 0.7
Min. =		Aug. 16	6.7	— 1.6

The first of these minima is somewhat less sure, on account of the gap from Oct. 30 to Nov. 21 in the series of observations. Moreover, the second and third minima, as well as the second maximum, are not very certain. On the other hand. the first maximum and, above all. the last two epochs are very accurate. Combining my epochs with Chandler's normal ones, I find

Max. = 1884 Dec. 13 $+130^{d}.3\,E$
Min. = Oct. 12 $+130.3\,E$

which formulas give the differences between observation and calculation for my epochs, as shown in the column O—C of the table above. I leave unconsidered the question whether these differences are due solely to errors of observation, or to anomalies in the light-variation. At any rate, the amplitude of the variation between the maximum of 1892 Feb. 7 and the minimum of March 29 is the smallest of all, as likewise the interval of time is the shortest. The very considerable amplitude of 1.7 mag. between 1892 June 11 and Aug. 16 is fully established. It must nevertheless be remarked that the magnitudes of the comparison-stars were not photometrically determined, but deduced by collation of the magnitudes in the *Durchmusterung*, by the aid of my step-estimates.

45. 7779 *S Cephei.*

Twenty-six observations, between 1891 Aug. 15 and 1892 March 29 give, not too uncertainly,

Max. = 1891 Dec. 28 ; Mag. = $9^{M}.2$

This brightness at maximum is remarkably low. By combining this epoch with Chandler's principal one, we obtain

Max. = 1881 May 16 $+485^{d}\,E$

and therefore precisely the period given by Schönfeld.

46. 8153 *R Lacertae.*

Seventeen observations in 1892 between Jan. 28 and Apr. 28, give

Max. = 1892 Feb. 23 ; Mag. = $8^{M}.3$

As late as Dec. 21 the star remained invisible. If my determination be combined with Chandler's principal epoch, we shall have, for the length of the period $299^{d}.4$ or $332^{d}.7$, according as we assume the number of periods to be 10 or 9.

47. 8600 *R Cassiopeae.*

I have made 16 observations of this star between 1890 Oct. 23 and 1891 Jan. 10. and then 60 between 1891 Aug. 12 and 1892 May 31. These give

Max. = 1891 Jan. 4 ; Mag. = $6^{M}.1$
Min. = Sept. 6 ; = 9.7
Max. = 1892 Mar. 3 ; = 5.7

The first two epochs are uncertain, inasmuch as the observations were not well distributed on the two sides. But the second maximum is very well determined.

Upsala, 1893 Jan. 21.

CORRECTION.

By a slip of the pen the name of the variable 7909. on p. 13. was written *R*; it should be *S Piscis austrini.*

S. C. Chandler.

CORRIGENDA.

No. 282, p. 141, col. 2, line 2. the Greenwich times should be diminished by 7^{h}.
No. 287, p. 182, col. 1, line 20, *for* reflected *put* neglected.
No. 290. p. 13. Decl. of the New Variable in *Aquila*, *for* —5° 35′.5 *put* —5° 53′.5.

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OBSERVATIONS, FROM 1888 TO 1893, OF STARS SUSPECTED OF VARIABILITY,

BY PAUL S. YENDELL.

F. 28 *Andromedae.*

$\alpha = 0^h\ 22^m\ 30^s.4 \qquad \delta = +28°\ 27'.3$ (1855).

This star has for some years been more or less suspected of variability: from 1888 Jan. 28 to 1891 Oct. 25, I have sixteen observations of it, all very accordant, the range being only from $6^M.0$ to $6^M.2$; the average magnitude is $6^M.1$.

(1367) *Tauri.*

$\alpha = 3^h\ 45^m\ 26^s \qquad \delta = +7°\ 20'.6$ (1855).

I have fifty-one observations of this star, from 1889 Nov. 15 to 1893 Feb. 5, ranging with exception of two, from $6^M.6$ to $7^M.2$. On the two exceptional occasions, 1892 Jan. 21 and 31, it was not seen with the field-glass, and must therefore have been below $8^M.0$. I have been unable to trace any regularity in the star's fluctuations.

(1805) *Orionis.*

$\alpha = 4^h\ 58^m\ 25^s \qquad \delta = +3°\ 54'.1$ (1855).

I have looked for this star on the following dates; 1892 Jan. 1, Mar. 6, Mar. 19, Oct. 31, Nov. 11, Nov. 24, Dec. 9 and 1893 Feb. 5; on each occasion, all the other *Durchmusterung* stars in the field of the telescope were identified, but I have never seen anything in the place of (1805), the limit of vision being usually assumed as 11^M or less.

38 (U.A.) *Leporis.*

$\alpha = 5^h\ 15^m\ 7^s \qquad \delta = -21°\ 22'.0$ (1875).

This star was announced as variable by Prof. ELLERY at the Melbourne Observatory in 1886, and estimates given, apparently showing a change of $0^M.8$, in a short period. SAWYER finds it constant. I have seven observations, from 1892 Nov. 16 to Dec. 11; these show an average departure of ± 1.4 step from a mean of $5^M.17$. The star is certainly constant.

F. 31 *Orionis.*

$\alpha = 5^h\ 22^m\ 22^s \qquad \delta = -1°\ 11'.7$ (1855).

Between 1889 Jan. 29 and 1892 April 9, I have forty-seven observations of this star, distributed as follows: 1889 Jan. 29 to April 19, twenty; from $5^M.1$ to $5^M.5$, average $5^M.3$; 1889 Nov. 5 to 1890 Jan. 16, six, from $4^M.9$ to $5^M.3$, average $5^M.1$; 1890 Dec. 7 to 1891 Mar. 11, nineteen, from $4^M.9$ to $5^M.7$, average $5^M.4$; 1892 Mar. 6 and April 9, both $5^M.3$.

With the exception of the third series of the above observations, the indications decidedly discourage the supposition of the star's variability; and the difficulty of observing, owing to its strong color, tends greatly to weaken the inference in favor of it from this series; my personal impression is strongly in favor of the star's constancy.

F. 39 *Aurigae.*

$\alpha = 5^h\ 54^m\ 37^s.9 \qquad \delta = +42°\ 59'.2$ (1855).

Of this star I have fifteen observations in November and December 1890, one in October 1891, and one in October 1892; these all give the star's magnitude as $6^M.0$, with the exception of 1890 Nov. 5, $5^M.9$. The color is very reddish.

(2305) *Lyncis.*

$\alpha = 6^h\ 20^m\ 14^s \qquad \delta = +58°\ 50'.6$ (1855).

One of CHANDLER'S List III, in the Supplement to his catalogue. I have twenty-four observations of it, from 1892 Jan. 1 to Nov. 9; of these, all but five are very accordant, the extreme limits of difference being $8^M.2$ and $8^M.4$; of the others, four, from Mar. 5 to 19, are $7^M.8$, and one, Oct. 29, is $7^M.9$. I strongly suspect a mistake in one of the comparison-stars in the March observations, and consider the evidence decidedly in favor of the star's constancy.

(5952) F. 33 *Herculis.*

$\alpha = 16^h\ 29^m\ 50^s \qquad \delta = +7°\ 23'.3$ (1855).

This star is one of List III, in the Supplement to CHANDLER'S Catalogue. I have about a hundred and seventy observations of it, in the seasons of 1889 to 1892. These appear to indicate variation, more or less irregular in both range and period, the light-curve indicated by my observations being very similar to those of *U Monocerotis* and *R Scuti*; the intervals between successive observed maxima and minima vary from fourteen to twenty-eight days, the mean period indicated being $20^d.6$.

The observed times of maxima and minima are as follows:

MAXIMA	w	Mag.	MINIMA	w	Mag.
1889 June 23.6	4	7.1	1889 June 30.3	3	8.0
July 17.5	4	7.2	July 23.6	4	8.0
31.3	3	7.0	Aug. 17.0	1	8.0
Aug. 28.4	3	7.5	Sep. 20.0	3	7.9
1890 May 22.4	4	7.0	1890 May 14.8	4	8.0
June 15.4	4	6.9	June 26.9	3	8.2
July 4.8	4	7.3	July 15.75	4	7.8
23.4	4	7.3	Aug. 3.6	4	8.0
Aug. 9.1	3	7.5			
1891 June 16.4	3	6.9	1891 July 5.4	3	7.7
1892 2.0	3	7.0			

The amplitude of the variation seems to differ considerably at different times, the average being about $0^{M}.8$, but the extremes being more than a whole magnitude apart; while at times for a considerable interval, the observations show no change beyond one or two steps. There appears to me to be no doubt that the star is actually variable.

(6943) *Sagittae.*

$\alpha = 19^{h}\ 15^{m}\ 13^{s}$ $\delta = +17^{\circ}\ 23'.1$ (1855).

I have five observations of this star, from 1892 July 20 to Sept. 10, as follows:

	M		M
1892 July 20,	9.9	1892 Aug. 29,	9.1
Aug. 15,	9.8	Sept. 10,	9.2
" 21,	9.4		

The evidence of these observations seems to favor the star's variability.

204 (U.A.) *Sagittarii.*

$\alpha = 19^{h}\ 28^{m}\ 26^{s}$ $\delta = -24^{\circ}\ 25'.9$ (1875).

Thirty-three observations of this star, made in 1889 and 1891 are rather indecisive as to its variability, ranging from $5^{M}.3$ to $6^{M}.0$, quite irregularly. The star is very red, and, as Sawyer (*A.J.* VIII, p. 124) remarks, very difficult to observe, and I do not attach much weight to the indications of variability afforded by my observations.

265 (U.A.) *Sagittarii.*

$\alpha = 19^{h}\ 54^{m}\ 58^{s}$ $\delta = -28^{\circ}\ 3'.3$ (1875).

My experience with this star corresponds substantially with Sawyer's (*A.J.*, VIII, p. 124). Fifty-four sequences, made in 1889 and 1891, appear to indicate fluctuations, which are very difficult to disentangle, in the whole group, which includes, with this star *c* (F. 62), *b*, ω and *A Sagittarii.*

DM. 39°4114.

$\alpha = 20^{h}\ 11^{m}\ 45^{s}.4$ $\delta = +39^{\circ}\ 54\,.9$ (1855).

This is Espin-Birmingham 660; Espin thinks probably variable, and gives various observations, from $5^{M}.2$ to $8^{M}.0$. I watched the star closely from 1892 Sept. 5 to Dec. 3, observing it thirty times; during the whole of this period my estimates are very accordant, giving a value of $6^{M}.2$, with the exception of Sept. 15, $6^{M}.4$, Sept. 21, $6^{M}.4$. and Sept. 25, $6^{M}.4$. I do not consider that my observations afford any evidence of variation during the period which they cover.

Dorchester, Mass., 1893 *Feb.* 11.

ρ *Capricorni.*

$\alpha = 20^{h}\ 21^{m}\ 44^{s}$ $\delta = -18^{\circ}\ 13'.5$ (1875).

This is No. 24 of Gore's Provisional List, the limits of change being given as $4^{M}.0$ to $6^{M}.0$. I have twenty-eight observations, from 1891 Aug. 22 to Oct. 17, which appear to indicate irregular changes from $5^{M}.2$ to $5^{M}.9$; I do not believe that the star is actually variable.

DM. 39°4208.

$\alpha = 20^{h}\ 23^{m}\ 34^{s}.3$ $\delta = +39^{\circ}\ 29'.9$ (1855).

Espin (Monthly Notices, Dec. 1891) says this star is variable, from $7^{M}.6$ to $11^{M}.2$. I have twelve observations, from 1892 Nov. 19 to Dec. 29, showing a range of from $8^{M}.5$ to $9^{M}.0$ only, which, in view of the star's strong orange color, afford no confirmation of its variability. The star is Espin-Birmingham 673.

DM. 33°4056.

$\alpha = 20^{h}\ 45^{m}\ 12^{s}.9$ $\delta = +33^{\circ}\ 57'.1$ (1855).

My attention was drawn to this star during the autumn of 1890, when it was tried as a comparison-star for *Y Cygni*, but discarded as being too nearly of the same brightness with the star *p*, (Chandler's notation), $7^{M}.9$. On 1891 Sept. 30, I found it $8^{M}.4$, and fifty-five observations from this date to 1892 Nov. 20, appear to indicate that the star has varied irregularly during the year, from $7^{M}.9$ to $9^{M}.0$. The D.M. magnitude is $8^{M}.4$.

DM. 38°4711.

$\alpha = 22^{h}\ 7^{m}\ 40^{s}.1$ $\delta = +38^{\circ}\ 59'.8$ (1855).

Chandler in his list of suspected stars (Annals H.C.O., Vol. 14, p. 471) quotes magnitudes by several authorities, from $4^{M}.5$ to $7^{M}.5$. Thirteen observations, from 1888 Jan. 30 to June 14, show a range of from $5^{M}.3$ to $5^{M}.7$ only, the mean being $5^{M}.5$; one observation. 1892 Oct. 23, gives $5^{M}.4$. The presumption seems to be against the star's variability.

DM. 48°3887.

$\alpha = 22^{h}\ 50^{m}\ 6^{s}.4$ $\delta = +40^{\circ}\ 57'.8$ (1855).

Chandler in his list of suspected stars (Annals H C.O., Vol. 14, p. 472) quotes magnitudes by various observers from $4^{M}.5$ to $6^{M}.5$. My five observations from 1888 Jan. 30 to July 3, are very accordant, ranging from $5^{M}.6$ to $5^{M}.8$. I have also an observation on 1892 Oct. 23, $5^{M}.4$. Probably constant. The star is very red.

OBSERVATIONS OF COMET *f* 1892 (*HOLMES*),

MADE AT THE HAVERFORD COLLEGE OBSERVATORY,

By Prof. WM. H. COLLINS and GEORGE L. JONES.

1893 Haverford M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$		Obs.
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ	
h m s			m s	' "	h m s	° ' "			
Jan. 20 9 19 27	1	10 , 5	+2 33.13	+1 36.5	1 27 10.18	+33 39 8.7	9.6703	0.4471	J
25* 8 48 55	2	10 , 5	−0 2.34	−6 46.0	1 34 12.37	+33 41 22.7	9.6153	0.4004	C
Feb. 4 8 42 9	3	10 , 5	+1 25.46	−6 49.0	1 48 51.85	+33 51 38.7	9.6704	0.4418	J

* $\Delta\alpha$ measured with micrometer.

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 24 37.62	—0.87	+33 37 24.0	+8.19	Weisse's Bessel I, 491
2	1 34 15.63	—0.92	+33 48 0.5	+8.15	Weisse's Bessel I. 726
3	1 47 27.37	—0.98	+33 58 19.6	+8.11	Weisse's Bessel I. 1047

FILAR-MICROMETER OBSERVATIONS OF COMET *f* 1892,

MADE WITH THE 26-INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA.

By EDGAR ODELL LOVETT.

[Communicated by Prof. ORMOND STONE, Director.]

1892–93 L.McC. M.T.		*	No. Comp.	☄ — *		☄'s apparent		log pΔ	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Dec. 20	9 23 57	1	5	. . .	+5 22.0	. . .	+34 30 0.7	. . .	0.129
	10 15 33		15	+1 13.05	. . .	0 53 15.45	. . .	9.640	. . .
	10 27 12		11	+1 13.47	. . .	0 53 15.87	. . .	9.658	. . .
	11 52 42		5	. . .	+4 59.5	. . .	+34 29 38.2	. . .	0.538
Jan. 12	8 39 9	2	28 , 12	—0 36.23	—0 11.8	1 16 56.39	+33 40 55.1	9.584	0.229
13	7 28 6		6	. . .	—0 50.8	. . .	+33 40 16.1	. . .	0.105
	7 55 53		21	+0 36.33	. . .	1 18 8.94	. . .	9.392	. . .
17	7 5 50	3	32	—1 32.80	. . .	1 23 14.50	. . .	9.344	. . .
	7 24 14		3	. . .	+1 35.0	. . .	+33 39 1.6	. . .	0.038
	7 41 25		24	—1 30.68	. . .	1 23 16.62	. . .	9.474	. . .
	9 8 32		9	. . .	+1 32.6	. . .	+33 38 59.2	. . .	0.350
19	6 43 59	3	32	+1 4.65	. . .	1 25 51.92	. . .	9.262	. . .
	7 9 28		6	. . .	+1 32.1	. . .	+33 38 58.6	. . .	0.110
	7 35 25		32	+1 7.88	. . .	1 25 55.15	. . .	9.471	. . .
	7 57 24		6	. . .	+1 32.2	. . .	+33 38 58.7	. . .	0.160
20	7 9 14	4	32	—0 35.70	. . .	1 27 14.2	. . .	9.351	. . .
	7 38 17		6	. . .	+0 39.4	. . .	+33 39.1	. . .	0.108
	8 0 54		32	—0 32.68	. . .	1 27 17.2	. . .	9.546	. . .
	8 24 16		6	. . .	+0 39.6	. . .	+33 39.1	. . .	0.189
	8 53 2		32	—0 30.03	. . .	1 27 19.9	. . .	9.644	. . .
	9 16 39		6	. . .	+0 39.7	. . .	+33 39.1	. . .	0.392
21	6 35 38	4	32 , 6	+0 43.84	+0 53.5	1 28 33.7	+33 39.3	9.245	9.925
	7 20 53		32 , 6	+0 46.28	+0 53.9	1 28 36.2	+33 39.3	9.442	0.062
	7 51 15		32 , 6	+0 48.14	+0 54.8	1 28 38.0	+33 39.3	9.527	0.154
23	6 26 0	5	16 , 3	+1 13.13	+4 33.7	1 31 17.16	+33 40 3.4	9.218	9.912
25	7 35 16	6	24 , 6	—0 5.92	—6 55.9	1 34 9.93	+33 41 7.4	9.515	0.138
26	7 25 24		20 , 6	+1 18.39	—6 13.3	1 35 34.23	+33 41 49.9	9.495	0.114
27	7 18 51		24 , 6	+2 43.65	—5 18.9	1 36 59.48	+33 42 44.2	9.483	0.100

Mean Places for 1892.0 and 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 51 59.77	+2.63	+34 24 10.6	+28.1	Paris 1225. Leiden Z.(2)
2	1 17 33.44	—0.82	+33 40 58.6	+ 8.3	Pi., d'A., B.Z. 439, Rümk., Paris. Leiden Z.
3	1 24 48.13	{—0.83 —0.86}	+33 37 18.2	+ 8.3	Leiden Zones(4), Paris, 1859
4	1 27 50.8	—0.87	+33 38.3	+ 8.3	DM. 33°255
5	1 30 4.93	—0.90	+33 35 21.6	+ 8.1	Leiden Zones
6	1 34 16.76	—0.92	+33 47 55.1	+ 8.1	Leiden Zones(2)

The position for star 2 was furnished by Prof. Boss; it was reduced with pr.m., +0s.018, +0″.11.

NOTES.

Dec. 20. Comet observed through wet haze. Faint, and nucleus seen with difficulty.

Jan. 12. Comet very faint and diffuse. Nucleus still visible. High wind.

Jan. 13. Growing fainter rapidly. Nucleus barely visible. Windy.

Jan. 16. Found in the place of comet Holmes what appeared to be a reddish yellow star in a fog. Bright nebulosity about 25″ in diameter. Clouded up before a micrometer measure could be made.

Jan. 17. Comet star-like. Nucleus very bright and well-defined. Color yellowish red. Seeing excellent.

Jan. 19. Visible to the naked eye. Apparently greater condensation. Change in color, the comet being decidedly bluish.

Jan. 20. Nucleus stellar, and as bright as on the 17th. Circular nebula around nucleus smaller and fainter.

Jan. 21. Comet bright and blue and larger. Seeing good.

Jan. 23. Circular nebula around nucleus, not so condensed, and more irregular in form, extending over an area twice as large as on the 16th. Nucleus larger and fainter. Moonlight and clouds.

Jan. 25. Nucleus not so well defined. Comet large and bright in moonlight. Growing fainter. Seeing good.

Jan. 26. Hazy and moonlight. Nucleus poorly defined.

Jan. 27. Comet diffuse. Nucleus very difficult to see. Appearance much the same as on the 12th. Moon and clouds. Seeing poor.

NOTE ON THE MASSES OF *MARS, SATURN, URANUS* AND *NEPTUNE*,

BY A. HALL.

In No. 288, p. 188 of this Journal I have given the value of a revolution of the screw of the micrometer of the 26-inch equatorial of the Naval Observatory, which appears to me the right value to be used in the reduction of all my measures of distance made with this instrument in the years 1875 to 1891. For the observations of double stars this change of value is of little importance, and generally it may be neglected; but in the determination of the masses of the planets, the new value should be introduced. I give below, therefore, these masses as they result from my measures of the distances of the satellites, using the new value of the screw.

$$R = 9''.9360.$$

The changes in the masses are indeed small, and sometimes are nearly within the limits of the probable errors, but it is well to reduce all these quantities to the standard which should be used in the reduction of my measures of distance.

Mars.

For the mass of this planet I use at present only the measures of distance in 1877, and the periods determined in 1879. An attempt to correct the mean distances from the observations of other years, by means of partial equations, would not, I think, be justified; and it is better to wait for the discussion of the complete equations of condition. The distances observed in other years show that the adopted mean distances are nearly correct. We have therefore the following quantities for this planet. The periods are expressed in mean solar days; the mean distances a, are those seen at the distance unity of the planet, and for convenience the reciprocals of the mass are given in the tables.

Satellite	Period	a	$\frac{1}{m}$
	d	″	
Phobos	0.3189113	12.9366	3089991 ± 10104
Deimos	1.2621349	32.3155	3106446 ± 3485

$$\text{Mass of } Mars = \frac{1}{3104700 \pm 3295}$$

Saturn.

The observations of *Mimas* and *Enceladus* are omitted in computing the mass of this planet, since these satellites were generally difficult to observe, especially the first, and small errors in the distances have too much influence on the result. The values of a are those seen at the distance 9.53885.

Satellite	Period	a	$\frac{1}{m}$
	d	″	
Tethys	1.8877978	42.683	3475.8 ± 10.63
Dione	2.7369140	54.668	3476.2 ± 8.38
Rhea	4.5174991	76.445	3462.9 ± 6.20
Titan	15.9454245	176 785	3487.7 ± 1.16
Iapetus	79.3310152	514.895	3494.0 ± 0.96

$$\text{Mass of } Saturn = \frac{1}{3490.8 \pm 0.73}$$

In the years 1875, 1876 and 1877, and again in 1889 and 1890, the difference of declination between *Saturn* and *Iapetus* was very small, and the mean distance of this satellite would depend almost wholly on the difference of right-ascension. An attempt was made therefore to determine the mass of the planet by a method nearly independent of the value of a revolution of the micrometer-screw. By observing the difference of right-ascension on the chronograph I found,

$$\begin{array}{lcrl} 1875, & a = & 515''.594 & \pm 0''.0559 \\ 1876, & a = & 515.454 & \pm 0.0583 \\ 1877, & a = & 515.517 & \pm 0.0526 \\ 1889\text{-}90, & a = & 515.304 & \pm 0.0640 \end{array}$$

Hence we have

$$a = 515''.479 \quad \pm 0''.0286$$

$$\text{Mass of } Saturn = \frac{1}{3482.2 \pm 0.53}$$

The results of the two methods differ by $\frac{1}{400}$ of the mass, and I think the mean may be taken as representing the final result of my observations.

$$\text{Mass of } Saturn = \frac{1}{3486.5}$$

On leaving this planet, with its wonderful system of Rings and satellites, I venture to call the attention of astronomers who have the use of large telescopes to the need of good observations of the inner satellites, *Tethys*, *Enceladus* and *Mimas*. The work of observing these faint objects, and discussing their motions, would be laborious, but in order to determine the mass of the Ring and its action, and that of the figure of the planet, such observations must be made.

Uranus.

The mass of this planet depends on my observations of the two outer satellites, since the inner ones, *Ariel* and *Umbriel*, are among the faintest objects I have ever observed, and they are of but little use for this purpose. The values of a are reduced to the distance of the planet 19.18338.

Satellite	Period	a	$\frac{1}{m}$
	d	″	
Titania	8.705897	31.318	22925 ±47
Oberon	13.163269	42.070	22682 ±34

$$\text{Mass of } Uranus = \frac{1}{22765 \pm 28}$$

Neptune.

For this planet, its mean distance from the sun was assumed to be 30.0551, and the results from my measurements are

$$\text{Period} = 5^{d}.876834\,; \quad a = 16''.349$$

$$\text{Mass of } Neptune = \frac{1}{19149 \pm 53}$$

1893 *February* 23.

ANCIENT ECLIPSES AND CHRONOLOGY,

By W. T. Lynn, B.A., F.R.A.S.

May I crave space for a few more lines with regard to Mr. Stockwell's contention that the years of the Greek Olympiads coincided with years of bissextile in the Roman Calendar? Most chronologists, on the other hand, take the bissextile year to have corresponded to a year preceding that in which an Olympic festival was held, and I think I have already shown that there is no reason to depart from this view, according to which the first year of an Olympiad would, in B.C. dates, fall in every even multiple of four years, and in A.D. dates in the years after such multiples, in B.C. 4 for instance, and in A.D. 1 and 5.

The principal reason apparently why Mr. Stockwell proposes to alter this is because he thinks it necessary to carry back the accepted date of the invasion of Greece under Xerxes by one year, making it B.C. 481, instead of B.C. 480. For we are told that an Olympic festival was held in the year of the invasion; and Herodotus speaks of a remarkable phenomenon in the sky while Xerxes was at Sardis, in the spring, which has been thought to have been caused by an eclipse of the sun. But as no such eclipse occurred in the spring of B.C. 480, modern writers have supposed that the appearance was meteorological. Mr. Stockwell, however, contends that the invasion took place a year earlier than the accepted date, and that the phenomenon in question was the eclipse of April 19 in B.C. 481. According, however, to the calculations of this eclipse by the late Dr. von Oppolzer, of Vienna, and others, its magnitude in Asia Minor was very small; and Mr. Stockwell's own investigations do but confirm this, making the obscuration of the sun at Sardis amount to less than a tenth of his diameter. There is no reason to suppose that such an eclipse would have been even noticed in those times; but the statement of Herodotus that the day was turned into night would require a total eclipse for the darkness to be caused in that way. Nor can I accept Prof. Rawlinson's view, that the historian "may, perhaps, have understood of the setting forth from Sardis what was told him of the departure from Susa in the spring of the preceding year." For, even at Susa, the magnitude of the eclipse was small, though much larger than at Sardis. It seems to me, therefore, that the old suggestion is right, and that the sudden disappearance of the sun, as reported to Herodotus, was caused by some atmospheric phenomenon.

But my main purpose in this communication is to call attention to an eclipse which occurred seventy-six years later, and is mentioned by Xenophon in the second book of his *Hellenics*. It took place in the year in which Athens was taken by Lysander in the spring, and the thirty tyrants commenced their rule in the autumn. The Attic year began in June, at the time of the Olympic festival, and Xenophon tells us that one was held in the summer of the year in question, which was also noted by an eclipse of the sun. Now, an annular eclipse (visible in Greece about 11 o'clock in the morning) did take place on the third of September, in the year B.C. 404, and there appears no reason to doubt that this is the one alluded to by Xenophon. Since, therefore, an Olympic festival was held in that year, it followed by one a year corresponding to a bissextile year, which would have fallen in B.C. 405. Seventy-six years before the latter, B.C. 481, would also have been a bissextile year; and in the year after that, B.C. 480, took place, as I believe, the invasion of Greece by Xerxes, and the famous battles of Thermopylae and Salamis.

Blackheath, London, S.E., England, 1893 *Feb.* 14.

CONCERNING THE ORBIT OF COMET III 1892, AND ON THE FLUCTUATIONS IN BRIGHTNESS OF THAT COMET,

By LEWIS BOSS.

Considering the past behavior of this comet it may be thought desirable to keep a watch upon its place for some time to come. In order to facilitate this purpose, I present herewith the results of a new calculation of its elements. These are based upon normal places derived from observations of Nov. 8 to Nov. 15 inclusive, 31 observations; Dec. 9 to Dec. 16, 16 observations; Jan. 16 to Jan. 21, 20 observations. Observations outside these limits were also taken in evidence. For the prompt communication of recent observations in advance of publication I am indebted to Prof. Barnard, to Prof. Stone and Mr. Lovett, and to Prof. Wilson. In making up the first normal place I find some improvement in the results of comparison with my former elements, exhibited in the *Journal*, no. 283. Prof. Barnard's result for δ on Nov. 10 is corrected in *A.J.*, no. 286, so that the residual $-29''.1$ in the published comparison (*A.J.* 283) becomes $-3''.2$; in like manner $\Delta\delta$ for the Lyons observation of Nov. 15 becomes $+0''.5$ instead of $+15''.4$ (for correction, see *A.N.* 3159, p. 308). My comparisons (*A.J.* 283, p. 150) for the Vienna observations of Nov. 13 were in error. They should read:

		Δα	Δδ	
	h m	s	″	
Nov. 13	5 34	+2.29	—23.4	H
	6 56	+0.58	+ 0.8	B

The adopted mean places for the comet on the respective dates are these:

Greenw. M.T.	α 1892.0	δ 1892.0	Corr. of former Ephemeris Δα	Corr. of former Ephemeris Δδ
	h m s	° ′ ″	s	″
1892 Nov. 12.0	0 44 36.22	+38 3 26.6	+0.30	— 0.9
Dec. 14.5	0 48 50.16	+34 54 29.8	+0.46	— 5.3
	α 1893.0	δ 1893.0		
1893 Jan. 18.5	1 24 34.31	+33 38 54.5	+2.03	—13.0

The elements which follow represent these positions with errors not exceeding $0''.1$ in any case.

Epoch 1892 Dec. 14.5 Gr. M.T.

$$M = 26^\circ\ 18'\ 27''.6$$

$$\left.\begin{aligned} \pi &= 345\ 53\ 28.8 \\ \omega &= 14\ 12\ 14.9 \\ \Omega &= 331\ 41\ 14.0 \\ i &= 20\ 47\ 16.5 \end{aligned}\right\}\ 1892.0$$

$$\begin{aligned} \varphi &= 24\ 11\ 52.4 \\ \mu &= 513''.9093 \\ \log a &= 0.5594134 \\ T &= 1892\ \text{June}\ 13.21138 \\ \log q &= 0.3303468 \end{aligned}$$

Period 2521.85 days.

The next perihelion passage is therefore due about May 10, 1899, and under rather less favorable relations than those which theoretically existed for the opposition recently passed.

The following table represents the amounts by which an ephemeris computed from these elements is corrected by a part of the observations which have been made since the outbreak in January. Having been obtained by differential processes they are not in all cases strictly rigorous, though the errors should not be material in any case. The observations which Mr. Lovett (Univ. of Va., except Feb. 13) transmitted to me are the results of a preliminary reduction.

It should also be mentioned that I have revised the star-positions in some instances, and particularly for observations based upon Pi. 56 = D'A. 272, 3. For this star I compute proper motions of $+0^s.018$ and $+0''.11$, and adopt the position for 1893.0: $\alpha = 1^h\ 17^m\ 33^s.44$; $\delta = +33^\circ\ 40'\ 58''.6$.

Comparison with Observation (O—C).

Place	Date	Δα	Δδ
		s	″
Strassburg.	Jan. 16.4	—0.03	— 0.5
Northfield.	16.6	—0.34	+ 3.7*
Mt. Hamilton,	16.7	+0.19	[—10.1]
Kiel,	Jan. 17.2	—0.05	— 0.1
Strassburg,	17.3	—0.04	— 0.1
Hamburg,	17.4	0.00	— 1.9
Univ. of Va.,	17.5	+0.40	+ 0.6
Mt. Hamilton,	17.6	—0.06	0.0
Hamburg,	Jan. 18.2	—0.04	— 1.7
Kiel,	18.2	+0.08	— 1.2
Strassburg,	18.3	+0.06	+ 0.2
Northfield,	18.6	—0.01	+ 0.3
Mt. Hamilton,	18.6	—0.14	+ 0.8
Northfield,	18.6	—0.13	— 0.5
Strassburg,	Jan. 19.3	+0.02	+ 0.6
Geneva,	19.3	+0.01	+ 1.0
Univ. of Va.,	19.5	+0.04	+ 2.5
Albany,	19.6	—0.09	— 1.2
Geneva,	Jan. 20.2	+0.07	— 1.2
Albany,	Jan. 21.5	+0.07	+ 0.5
Univ. of Va.,	Jan. 25.5	+0.13	— 5.7
Univ. of Va.,	Jan. 26.5	0.00	— 5.7
Univ. of Va.,	Jan. 27.5	—0.10	+ 0.5
Univ. of Va.,	Feb. 13.6	+0.50	— 2.7

* Large Δδ for (☄—✱)

Taking into account the apparent precision of these observations, together with the satisfactory representation of the totality of observations since discovery, it becomes quite evident that there has been no very great displacement of the nucleus during the recent outburst. A total angular displacement of 10″, at right angles to the line of vision would have implied an actual displacement of little more than 10 000 miles. To have produced this displacement within five days would have required an alteration of less than one-fourth of one per cent. (0.0025) in the orbital velocity of the comet, which at the time of the outburst in January was moving very nearly at right angles to our visual line. It is difficult to suppose that a collision, of sufficient violence to have produced the great increase of brightness which was observed, would not have produced a displacement of the nucleus that would have been easily measurable.

A similar argument might apply in some degree against the assumption of an explosion, not absolutely symmetrical, on a scale sufficient to disrupt a nucleus composed of solid matter, and to drive the fragments violently apart. Perhaps, in making such an assumption, one might suppose an explosion of comparatively little violence with the scattering of a cloud of dust, or the release of imprisoned gases. Both in the days following the outburst in January and after discovery, Nov. 6 (previous to which it is probable that an outburst had occurred), the nebulous envelope of the comet was observed to be in a state of rapid apparent expansion. Supposing this to have been due to projectile velocities, mechanically imparted to particles of dust, would imply a violent initial shock; in which case a little reflection would show that it would be necessary to suppose that the disruptive energy must have acted with remarkable and, perhaps, incredible symmetry in every direction. If it is considered that the increase of brightness may have been due to the ignition and incandescence of uprushing gases, the spectroscope should have made us aware of that fact. Yet it is notable that the spectrum of this comet has not shown even the usual cometary bands, much less the bright lines of incandescent gases.

On the other hand, it is not necessary to suppose that dust particles were driven off from the nucleus by ordinary mechanical agencies alone, nor that uprushing gases would need to become incandescent in order to be visible. The objection to what might be termed the eruptive hypothesis lies in the difficulty of accounting for the occurrence of an eruption at times when we must suppose that the temperature of the comet had been decreasing for a long period. Then, too, the difficulty of accounting for two successive eruptions of nearly equal magnitude must be considered as vastly greater than that of accounting for only one — if not, indeed, as insuperable. Therefore, while the eruptive hypothesis may be considered not to be entirely outside the pale of permissible speculation, the admission of it seems to be beset with difficulties which make some other plausible explanation worthy of attention.

That the brightness of comets may be due in part to electrical action, of a nature similar to that which produces the terrestrial aurora, seems to me to be a hypothesis that offers fewer objections than any other which has been proposed. It has appeared to me extremely probable that the corona of the sun is also of a nature analogous to that of our aurora. For the existence of auroral manifestations near a celestial body, it may be assumed that surrounding space filled with matter in a finely divided state and of extreme tenuity is most favorable. The upper regions of the earth's atmosphere, in which the aurora is formed, are undoubtedly of this nature. Much evidence exists to prove that the matter which fills the coronal regions about the sun is also of this description. The evidence to this effect is still more conclusive as to the physical constitution of the envelopes and tails of comets.

That there is an electro-magnetic action between the sun and the earth may be regarded as an established fact, which is evidenced by the synchronism of the periods of solar disturbance with those of auroral displays and of the elements of terrestrial magnetism, — with special and much more striking coincidences of this kind on occasions of unusually intense disturbances. It is entirely natural and reasonable to suppose that this form of inter-cosmical action also obtains between the sun and other bodies of the solar system. Considering the enormous extent of the nebulous surroundings of comets, together with other facts concerning their physical constitution and the variation of their distances from the sun with probable coincident variation in temperature, it seems not unreasonable to suppose that the action of electro-magnetic energy from the sun upon these bodies may be far more intense and persistent than is the case with other bodies of the solar system.

The development of cometary tails may be completely explained through the agency of a supposed form of energy acting from the sun in a sense contrary to that of gravitation. It is physically possible that this energy may be synonymous with electrical repulsion due to similar electrifications. The electrical-repulsion hypothesis to account for the development of the tails of comets was suggested by Olbers, and has found favor with many special students of this subject. There is a mass of carefully collected mathematical and physical evidence in support of this view, which has already been placed on record in the works of Zöllner, Bredichin and others; and no objections, or counter-evidence, of weight have been presented.

According to the electrical-repulsion hypothesis the molecules of matter composing the nebulous envelope are repelled not only by the sun, but also by the nucleus of the comet. This action of the nucleus was taken into account by Bessel in his classical paper upon the tail of Halley's comet, and is a necessary factor in all refined investigations of this kind. In case of any unusual electrical disturbance in a comet, the first effect would be the repulsion by the nucleus of the matter composing the coma, and the latter would expand on all sides. This expansion would take place quite symmetrically, until the molecules acted upon reach a distance from the nucleus where the repulsive action of the sun becomes proportionally large in comparison with that of the nucleus. Then the molecules would be driven back to form the tail. This seems to be precisely what took place with the comet of Holmes subsequent to discovery, and the matter, fresh in mind, does not appear to call for a detailed exposition at the present time. Furthermore, the more intense the initial electrical disturbance in the central parts of the comet, the greater would be the expansion of the coma before the peculiar action of tail-formation would become strikingly manifest; and a mathematical development of the resultant energies brought into action will show that, under the circumstances described, the tail would be extremely broad and diffused in comparison with the tails of other comets produced under less sudden and violent electrical excitation in the nucleus.

Every one who has had much experience in the observation of comets must have been impressed with the belief that after making all due allowances for the varying transparency of the atmosphere on different occasions, the brightness of telescopic comets does materially vary without strict reference to the relations of distance, and by no means with regularity. The variations in brightness of the periodic comets, at their successive returns to perihelion, seem to be largely independent of theoretical relations depending upon their relative distances from the sun and earth. There have been notable instances of abnormal temporary variation in brightness of comets, such as that of the relative brightness of the two fragments of Biela's comet, the outbursts of Comet 1888 I (Sawerthal), and others. The hypothesis that a part of the light of comets comes from electrical excitation in the nebulous envelopes, seems to afford the readiest and most reasonable explanation for these variations of brightness, — the only apparent drawback being that the adoption of this hypothesis might call for a reason why the abnormal variations in the brightness of comets are not more frequent and decided. In all probability the visibility of comets is largely, if not chiefly, due to reflected sunlight, which would give a constant element of brightness that would serve to render the abnormal changes less striking.

The presence of bright bands in the spectra of comets implies incandescence of the matter composing them. Considering the tenuity of the nebulous envelopes of comets, in connection with their volume and the minuteness of the nuclei, and taking into account the probable low temperature of space, it is quite certain that this incandescence is not due to heat in its ordinary form (*i.e.* from non-electrical sources of heat), and it seems to be impossible to account for it otherwise than as a manifestation of some form of electrical action. This, at least, would seem to be the case with by far the greatest number of comets, excepting only the few that approach the sun so nearly as to be subjected to a solar radiation sufficient to produce incandescence.

Finally, it may be asserted that the physical appearance of comets is not opposed to this hypothesis of auroral origin for a part of the light, but that, on the contrary, it is quite favorable to that hypothesis. At the distances from which comets are viewed, the form and pulsations of individual streamers should be entirely invisible, as would be, under like circumstances, the details of the terrestrial aurora. All that it would be necessary to assume is that this auroral action is more uniform in the surroundings of comets than in those of the earth.

Whatever may be the cause of the fluctuations in the brightness of the comet of Holmes it may be considered desirable to keep a watch upon its place for some time after it shall have become too faint (perhaps temporarily) for observation. To aid in maintaining such watch the subjoined Ephemeris has been prepared by my assistants, Messrs. Lay and Benton, who have also assisted in the computations for the Elements.

Ephemeris for Greenwich Midnight.

1893	App. α	App. δ	log. Δ
	h m s	° ′ ″	
Mar. 22.5	3 6 16.0	+35 44 43	0.52869
26.5	3 13 31.3	+35 55 54	0.53582
30.5	3 20 49.5	+36 6 54	0.54269
Apr. 3.5	3 28 10.5	+36 17 36	0.54929
7.5	3 35 33.9	+36 27 58	0.55565
11.5	3 42 59.5	+36 37 55	0.56174
15.5	3 50 26.7	+36 47 25	0.56757
19.5	3 57 55.5	+36 56 24	0.57314
23.5	4 5 25.4	+37 4 51	0.57846

COMETS OF THE YEAR 1892.

The dates are in Greenwich Mean Time, and the Elements only approximate.

Designation	Perihelion	☊	ω	i	q	ϕ	Discoverer	Date	Synonym	
		° ′	° ′	° ′		° ′				
I	April 6.67	240 55	24 32	38 43	1.027		Swift	Mar. 7	*a*	
II	May 11.18	253 26	129 19	89 42	1.971		Denning	Mar. 18	*c*	
III	June 13.21	331 41	14 12	20 47	2.140	24 12	Holmes	Nov. 6	*f*	Periodic; $6^{y}.9$
IV	June 30.89	104 5	172 6	14 32	0.886	46 33	Spitaler	Mar. 18	*b*	Periodic of Winnecke
V	Dec. 10.820	206 39	170 14	31 12	1.429	35 32	Barnard	Oct. 12	*e*	Periodic; $6^{y}.3$
VI	Dec. 28.09	264 28	252 41	24 48	0.976		Brooks	Aug. 28	*d*	
—	1893 Jan. 6.52	185 39	85 14	143 52	1.195		Brooks	Nov. 19	*g*	

The comet *g* 1892 is probably 1893 I.

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ON THE CONSTANT OF ABERRATION,

By S. C. CHANDLER.

II.

§3. Peters's Vertical-Circle Observations of Seven Stars, 1842–43.

The observations were taken from the same sources as those of *Polaris*, §2. The values of n in Table II were formed with the following values of δ'_0: *α Aurigae*, +45° 49′ 58″.52; *ι Ursae Majoris*, +48° 38′ 43″.54; 1830 Groombridge, +38° 49′ 49″.06; *α Bootis*, +19° 59′ 30″.63; *α Lyrae*, +38° 38′ 33″.63; *α Cygni*, +44° 43′ 44″.08; 61 *Cygni*, +37° 59′ 24″.72. The following corrections were made to the data in Vol. V, *Pulk. Obs.*, and may be justified by reference to the reductions in Vol. IV.

ι Ursae Maj.,	1842 Sept. 12	for	42″.94	read	43″.91
" " "	1813 May 24	"	42.99	"	43.99
α Lyrae,	1842 July 6	"	33.88	"	32.88

Also, an observation of *α Aurigae*, 1842 May 22, given by Peters in his *Recherches*, is omitted in the Pulkowa volumes, for some reason not apparent.

It is manifest that the interval comprised by the observations is insufficient to give the constants of both terms of the latitude-variation. The process adopted, therefore, was to apply to the n s of Table II the periodical variation found for *Polaris*, eq. (39); and, with these corrected values, to solve according to (35), omitting the terms in y and z, *i.e.*,

$$X + Y\sin\odot + Z\cos\odot = n \qquad (40)$$

then, writing $d\eta$ and $d\zeta$ for η and ζ in (37), to solve for those quantities and n. Thus we have first, by the formation and solution of the equations for the several stars, according to (40): —

	X	Y	w_1	Z	w_2
α Aurigae,	+0″.0407	+0″.0808	13.3	−0″.1296	20.8
ι Ursae Maj.,	− .0714	+ .2034	11.4	+ .0596	16.1
Gr. 1830,	+ .2482	+ .0184	8.6	− .2453	3.2
α Bootis,	+ .0134	+ .0110	29.3	− .1128	31.9
α Lyrae,	+ .0257	− .0240	18.5	+ .0592	29.5
α Cygni,	− .0141	+ .0919	19.8	− .0084	55.0
61 *Cygni*,	+0.1482	−0.1674	10.6	+0.2498	23.7

The substitution of X, Y and Z, in the observation-equations gives the column v in Table II.

By (27), (37) and (38),

α Aurigae,	$+0.1704\,d\eta$	$-0.3617\,d\zeta$	$+0.1599\,u$	$= +0''.0607$	$w_0 = 118.2$
ι Ursae Maj.,	$-\ .5032$	$-\ .2481$	$+\ .3147$	$= -\ .1171$	$= 38.5$
Gr. 1830,	$-\ .6257$	$+\ .2696$	$+\ .4643$	$= -\ .0776$	$= 14.7$
α Bootis,	$-\ .2898$	$+\ .5409$	$+\ .3766$	$= -\ .0651$	$= 83.1$
α Lyrae,	$+\ .0858$	$+\ .8784$	$+\ .7790$	$= +\ .0499$	$= 37.7$
α Cygni,	$+\ .4429$	$+\ .7843$	$+\ .8114$	$= +\ .0341$	$= 47.4$
61 *Cygni*,	$+0.4347$	$+0.7132$	$+0.6976$	$= +0.1054$	$= 25.5$

which give the normal equations,

$$\begin{array}{rrrl} +40.304\,d\eta & +\ 9.206\,d\zeta & +11.053\,u & = +7''.815 \\ +\ 9.206 & +114.429 & +77.570 & = +0.124 \\ +11.053 & +\ 77.570 & +88.273 & = +1.811 \end{array}$$

and the values of the unknowns,

$$d\eta = +0''.1946 \quad , \quad d\zeta = -0''.0296 \quad , \quad u = +0''.0222$$

Consequently the definitive value of the aberration-constant from this series is,

20″.467

Adding $d\eta$ and $d\zeta$ to the η and ζ got from *Polaris*, we have, by (30), $G' = 312°.8$, and $r_2 = 0''.215$. Substituting $d\eta$ and $d\zeta$ for η and ζ in (36), we have the aberrations for the several stars, and their parallaxes, in column I.

	w	I		II		Peters	
		Aberr.	π	Aberr.	π	Aberr.	π
		″	″	″	″	″	″
α Aurigae,	0.16	20.550	(—0.364)	20.532	(—0.294)	20.928	(+0.046)
ι Urs. Maj.,	.31	.361	— .136	.401	— .158	.150	+ .133
Gr. 1830	.46	.557	+ .393	.610	+ .325	-	+ .226
α Bootis	.38	.464	+ .323	.435	+ .301	.227	+ .127
α Lyrae	.78	.521	+ .256	.539	+ .285	.465	+ .103
α Cygni	.81	.409	+ .111	.434	+ .128	.428	— .082
61 *Cygni*	0.70	20.505	+0.544	20.525	+0.585	20.553	+0.319

In column II are placed the results which I have similarly and independently derived from a computation based on the values of *n* given by Peters, pp. 108–119 of his memoir, after applying the ulterior corrections for flexure, thermometric refraction-coefficient and proper motion. For the last I have used Gould's value for 1830 Groombridge (Gould's D'Agelet, p. 31), and Boss's for the other stars. Under the heading Peters are given the results of his discussion. Their comparison with those of the present one shows how greatly the divergences in the aberrations are reduced by the elimination of the latitude-variation. As to the parallaxes, the value for *α Aurigae* is of no significance whatever, for the reasons stated by Peters. Indeed, only those of the last three stars are entitled to any confidence. The result for 61 *Cygni* is especially satisfactory; Peters's value of 0″.319 being now brought up to 0″.544, thus perfectly in line with the most trustworthy micrometric determinations; Struve, 0″.511, and Auwers, 0″.564.

Table II. Peters's Vertical-Circle Observations of Seven Stars, 1842–43.

t	w	n	v
α Aurigae.			
1842		″	″
Mar. 19	7	+0.06	+0.19
Apr. 8	3	+ .50	+ .61
May 4	2	— .20	— .14
18	3	— .28	— .26
29	5	— .09	+ .04
June 21	2	+ .08	00
Aug. 3	7	+ .12	— .07
13	5	+ .39	+ .19
Oct. 23	1	+ .10	— .06
Nov. 25	1	— .14	— .20
Dec. 17	1	+0.32	+0.34
1843			
Feb. 5	2	—0.28	—0.13
20	4	— .39	— .23
Mar. 5	1	— .26	— .10
18	5	—0.31	—0.16
[*wnn*], [*wvv*]		3.45	2.38
ι Ursae Majoris.			
1842		″	″
Mar. 21	1	—0.27	—0.22
May 2	7	— .01	— .06
14	2	— .10	— .16
27	6	+ .20	+ .12
June 6	4	+ .17	+ .08
Sept. 11	3	+ .08	+ .14
22	3	— .19	— .10
Nov. 17	1	—0.63	—0.39
1843			
Feb. 6	2	+0.10	+0.30
22	2	00	+ .15
Mar. 7	1	— .09	+ .02
17	3	— .27	— .19
Apr. 27	3	+ .24	+ .17
May 24	2	—0.22	—0.36
[*wnn*], [*wvv*]		1.19	1.15
Groombridge 1830			
1842		″	″
Mar. 22	4	—0.04	0.00
Apr. 6	4	—0.25	—0.21
Groombridge 1830. — Cont.			
1842		″	″
Apr. 14	5	+0.09	+0.12
24	3	— .09	— .09
May 2	3	— .16	— .18
10	3	+ .20	+ .16
Nov. 17	1	+ .50	+ .09
Dec. 7	1	0.00	—0.26
1843			
Jan. 19	1	+0.12	+0.03
Feb. 4	3	+ .09	+ .06
Mar. 12	2	— .22	— .16
21	7	+ .08	+ .13
Apr. 2	3	— .08	— .05
20	3	+ .08	+ .08
28	5	+0.02	—0.01
[*wnn*], [*wvv*]		0.99	0.73
α Bootis.			
1842		″	″
Apr. 27	3	—0.02	+0.11
May 7	3	+ .12	+ .23
14	4	— .36	— .26
25	5	— .10	— .02
June 2	5	— .34	— .28
10	3	— .18	— .14
22	3	— .11	— .10
Aug. 6	4	+ .27	+ .16
14	8	+ .21	+ .09
21	3	+ .55	+ .42
Sept. 5	1	+ .17	+ .02
15	3	+ .20	+ .04
Oct. 21	3	— .16	— .31
Nov. 16	4	— .12	— .22
Dec. 6	2	—0.14	—0.18
1843		″	″
Feb. 4	3	+0.11	+0.22
22	2	+ .28	+ .42
Mar. 7	1	— .54	— .38
19	3	+0.02	+0.17
α Bootis. — Cont.			
1843		″	″
May 2	3	+0.16	+0.25
24	6	— .37	— .34
June 3	4	+ .16	+ .17
14	5	— .11	— .14
22	3	+0.52	+0.46
[*wnn*], [*wvv*]		5.56	4.68
α Lyrae.			
1842		″	″
Apr. 8	3	+0.38	+0.37
17	3	+ .08	+ .08
June 6	4	— .05	— .01
22	4	— .28	— .23
July 6	5	+ .11	+ .15
22	4	— .20	— .16
Sept. 11	5	— .03	— .03
19	5	+ .14	+ .14
Oct. 12	7	+ .01	— .01
27	1	+ .06	+ .02
Dec. 19	4	+0.04	—0.02
1843			
Mar. 4	2	—0.44	—0.48
20	2	+ .15	+ .12
29	4	—0.02	—0.05
[*wnn*], [*wvv*]		1.54	1.46
α Cygni.			
1842		″	″
Mar. 17	3	+0.13	+0.20
Apr. 1	4	— .32	— .26
11	4	— .27	— .21
18	4	+ .15	+ .21
28	4	— .07	— .03
May 4	2	— .02	— .01
11	4	+ .17	+ .18
June 24	2	— .08	— .11
July 4	3	— .15	— .20
10	2	+0.14	+0.08
α Cygni. — Cont.			
1842		″	″
July 27	3	+0.13	+0.08
Aug. 3	4	— .05	— .11
8	4	+ .03	— .03
13	5	+ .14	+ .08
20	5	+ .06	.00
Sept. 27	3	— .04	— .07
Oct. 10	4	.00	— .01
15	3	— .12	— .12
24	3	+ .25	+ .26
Nov. 18	3	—0.10	—0.05
1843			
Feb. 12	2	—0.23	—0.11
Mar. 30	3	+ .08	+ .13
Apr. 17	5	+ .01	+ .03
26	6	— .04	— .03
May 22	2	+0.19	+0.14
[*wnn*], [*wvv*]		1.76	1.54
61 *Cygni.*			
1842		″	″
Apr. 20	2	+0.55	+0.34
25	4	+ .24	+ .06
May 10	3	+ .08	— .03
July 4	3	— .24	— .14
10	2	— .18	— .06
24	4	— .20	— .06
Aug. 2	2	— .32	— .18
10	8	+ .05	+ .19
19	5	— .08	+ .05
27	3	— .13	.00
Oct. 10	4	— .29	— .30
19	4	+ .32	+ .27
Nov. 18	2	— .06	— .25
1843			
Apr. 25	7	+ .26	+ .05
May 22	2	—0.51	—0.61
[*wnn*], [*wvv*]		3.31	2.26

§4. Gyldén's Vertical-Circle Observations of *Polaris*, 1863-70.

These observations were used as they appear in Nyrén's memoir on the Latitude of Pulkowa, and were treated in a precisely similar way to those of Peters, §2; namely, by forming simultaneous means for the two culminations. In doing this a few observations had to be excluded for want of corresponding observations at the other culmination, reducing the weights from 129 to 119 for U.C., and from 109 to 104 for L.C. Table III gives the values of n_1 and n_2 by eq. (31). Using the assumed values, $\theta = 0°.843$, $T'_0 = 2\,402\,811$, forty-eight equations were formed according to (32), resulting in the normal equations.

$$\begin{array}{rrrrrl}
+195.00x & +11.68y & +\ 29.17z & +26.41\eta & +\ \ 3.25\zeta & = -\ 8''.44 \\
+\ 11.68 & +86.69 & -\ \ 6.31 & +12.77 & -\ 30.43 & = -\ 5.68 \\
+\ 29.17 & -\ 6.31 & +108.08 & +\ 4.62 & +\ 31.85 & = -23.43 \\
+\ 26.41 & +12.77 & +\ \ 4.62 & +66.21 & +\ 41.60 & = +\ 2.00 \\
+\ \ 3.25 & -30.43 & +\ 31.85 & +41.60 & +128.79 & = -\ 8.78
\end{array}$$

the solution of which gives,

$$\begin{array}{rl|rl}
x = & -0.0232 & \theta\,.\,\Delta T = & +33°.5 \\
y = & -0.1300 & \Delta T = & +39^{d}.8 \\
z = & -0.1962 & T'_1 = & 2\,402\,851 \\
\eta = & +0.1373 & r_1 = & 0''.235 \\
\zeta = & -0.0941 & G' = & 304°.4 \\
 & & r_2 = & 0''.166
\end{array}$$

whence by (24),

$$\begin{aligned}\varphi = 59°\,46'\,18''.647 &- 0''.235\cos(t - 1866\ \text{Sept. }6)\times 0°.843 \\ (41)\qquad &- 0''.166\cos(\odot - 304°.4)\end{aligned}$$

Nyrén's value from these observations was 59° 46′ 18″.654.

The substitution of the unknowns gives the residuals (O—C) in the column v_1 of Table III. An exceedingly important feature of these residuals can only be noted here in passing. Near the beginning they are in general positive, but toward the end they are as generally negative, thus implying a slow decrease of the mean latitude during the series. When we present Nyrén's series it will be seen that the mean latitude for the earlier part of it is practically identical with that here shown by the end of Gyldén's. This curious result is entirely accordant with the indication of a gradual diminution of the Pulkowa latitude which Nyrén remarked, in Vol. XIV of the *Pulkowa Observations*, from the discussion of the Pulkowa declinations in general. Combined with similar indications found by Gould in the Cordoba observations, and which present themselves also in other series, it leads to the presumption of a term of long period in the latitude spoken of near the end of §1.

With the values of n_2 in Table III we form equations of condition according to (33), and arrive at the normal equations.

$$\begin{array}{rrrl}
+195.00(-\xi) & +26.41\,Y & +\ \ 3.25\,Z & = +7''.16 \\
+\ 26.41 & +66.21 & +\ 41.60 & = +1.13 \\
+\ \ 3.25 & +41.60 & +128.79 & = +4.28
\end{array}$$

the solution of which gives,

$\xi = -0''.0393$, $Y = -0''.0237$, $Z = +0''.0399$

whence, by (34), $u = -0''.0340$ and $\pi = +0''.0458$. The definitive values are, then,

Aberration, **20″.411**; Parallax of *Polaris*, **+0″.046**.

This aberration is a very material reduction from Nyrén's from the same observations, which was 20″.469. The parallax is a notable increase of his value of +0″.006.

As a general rude control of the computation, if we correct Nyrén's values of n, pp. 23–27 of his memoir, for the variation of latitude according to (41), and repeat his solution, we find, in our present notation,

$x = -0''.019$, $\xi = -0''.039$, $u = -0''.031$, $\pi = +0''.019$

The aberration-correction is here sensibly the same as given by the above definitive solution; but the difference in the parallax is unaccountably large.

Table III. Gyldén's Vertical-Circle Observations of *Polaris*, 1863-70.

t	w	n_1	v_1	n_2	v_2
1863-64		″	″	″	″
Nov. 18	5	+.07	—.03	+.03	—.01
Dec. 16	3	—.04	.00	+.01	—.05
26	2	—.14	—.06	+.14	+.07
Mar. 7	3	—.15	+.14	—.07	—.16
19	4	—.18	+.12	+.02	—.05
Apr. 22	8	—.12	+.13	+.03	—.03
May 11	5	—.21	.00	—.01	—.05
June 7	3	—.06	+.05	+.09	+.06
24	4	+.09	+.14	+.05	+.01
July 5	4	—.10	—.08	+.02	+.01
12	3	+.12	+.11	+.05	+.05
Sept. 7	3	+.06	—.10	+.11	+.12
19	5	+.27	+.09	—.04	—.04
Oct. 5	5	+.31	+.12	—.09	—.09
14	3	+.41	+.23	+.07	+.06
23	5	+.36	+.18	—.09	—.11
1864-65-66-67		″	″	″	″
Nov. 6	3	+.14	—.02	+.04	+.01
Dec. 7	2	+.15	+.05	+.15	+.10
Mar. 15	5	—.12	—.02	+.05	—.03
24	8	—.03	+.09	+.11	+.03
Apr. 5	6	—.20	—.07	+.14	+.07
14	5	—.21	—.08	—.09	—.16
21	6	—.16	—.02	.00	—.06
30	5	—.17	—.04	—.04	—.10
May 10	4	—.25	—.11	+.02	—.03
Sept. 22	5	—.07	—.04	+.06	+.06
Oct. 2	5	—.03	—.01	+.01	.00
Sept. 9	2	+.06	+.20	—.07	—.06
24	5	—.23	—.07	—.04	—.04
Oct. 27	4	—.33	—.13	+.03	+.01
Apr. 26	2	+.41	+.20	+.10	+.04
May 16	2	+.35	+.10	+.12	+.08
1867-68-69-70		″	″	″	″
Oct. 11	8	—.24	—.04	+.06	+.05
14	3	—.39	—.18	+.20	+.19
27	4	—.32	—.06	+.01	—.01
Nov. 16	3	—.06	+.25	—.16	—.20
Mar. 19	3	—.24	—.22	+.17	+.10
Apr. 3	5	—.23	—.28	+.14	+.07
May 11	3	+.12	—.12	+.16	+.12
June 24	4	+.32	—.02	—.26	—.27
July 1	4	+.70	+.35	—.08	—.09
Oct. 5	4	—.28	—.28	+.06	+.06
19	2	—.19	—.09	—.12	—.13
Apr. 22	4	—.04	—.01	+.10	+.04
May 15	3	—.09	—.20	+.07	+.03
July 9	3	+.07	—.28	+.24	+.24
Oct. 26	2	+.03	—.04	+.10	+.08
Mar. 29	6	—.22	+.10	+.26	+.18
[wnn], [wvv]		10.13	3.50	2.16	1.71

§5. Nyrén's Vertical-Circle Observations of *Polaris*, 1871–75.

These observations were taken from the same source, and treated in the same way as those in §2 and §4. Table IV gives the values of n_1 and n_2 by eq. (31). Using the same values as in §4, $\theta = 0°.843$, $T'_0 = 2\,402\,811$, thirty-six equations were found according to (32), resulting in the normal equations,

$$\begin{array}{rrrrrcl}
+163.00\,x & -53.05\,y & -14.03\,z & +58.80\,\iota & +40.62\,\zeta & = & -23.41 \\
-\ 53.05 & +90.41 & +\ 0.41 & -18.22 & -73.96 & = & +\ 4.72 \\
-\ 14.03 & +\ 0.41 & +72.53 & +18.21 & -\ 8.71 & = & -\ 7.67 \\
+\ 58.80 & -48.22 & +18.21 & +75.39 & +37.97 & = & -\ 8.09 \\
+\ 40.62 & -73.96 & -\ 8.71 & +37.97 & +87.70 & = & -\ 3.70
\end{array}$$

the solution of which gives

$$\begin{array}{rcl|rcl}
x & = & -0''.1899 & \theta\,.\,\Delta T & = & +24°.1 \\
y & = & -0.0741 & \Delta T & = & +28^{d}.6 \\
z & = & -0.1655 & T_1' & = & 2\,405\,402 \\
\iota & = & +0.0640 & r_1 & = & 0''.181 \\
\zeta & = & -0.0609 & G' & = & 313°.5 \\
 & & & r_2 & = & 0''.088
\end{array}$$

whence by (24)

$$\varphi = 59°\,46'\,18''.480 - 0''.181\ \cos(t - 1873\text{ Aug. }31) \times 0°.843 - 0''.088\cos(\odot - 313°.5) \qquad (42)$$

The substitution of the unknowns gives the residuals (O—C) in the column v_1 of Table IV.

It is convenient to adjourn the discussion of the existence of the long-term period in the latitude, spoken of on page 178, until the results of the Pulkowa prime-vertical observations, 1840–1862, and 1879–1882, and other series have been presented.

For the aberration we first take the first nineteen values of n_2 in Table IV, corresponding to the data used by Nyrén in his discussion. Forming equations of condition according to (33), we get the normal equations,

$$\begin{array}{rrrcl}
+94.00(-\xi) & +\ 8.07\,Y & +20.14\,Z & = & +17''.58 \\
+\ 8.07 & +26.81 & +18.87 & = & +\ 3.79 \\
+20.14 & +18.87 & +67.24 & = & +\ 6.12
\end{array}$$

the solution of which gives,

$$\xi = -0''.1769\,, \quad Y = +0''.0764\,, \quad Z = +0''.0166$$

whence, by (34), $u = +0''.0695$ and $\pi = +0''.0375$.

The last seventeen values of n_2 of Table IV give the normal equations,

$$\begin{array}{rrrcl}
+69.00(-\xi) & +50.73\,Y & +20.48\,Z & = & +15''.34 \\
+50.73 & +48.58 & +19.10 & = & +12.43 \\
+20.48 & +19.10 & +20.46 & = & +\ 5.72
\end{array}$$

whence,

$$\xi = -0''.1451\,, \quad Y = +0''.0814\,, \quad Z = +0''.0583$$

consequently, $u = +0''.0627$ and $\pi = +0''.0795$.

The solution of all thirty-six equations gives

$$u = +0''.0596 \quad \text{and} \quad \pi = +0''.0447$$

The substitution of the above unknowns, for each set of equations, gives the residuals (O—C) in the column v_2 of Table IV.

The definitive values are, from the whole series,

Aberration, **20″.505**; Parallax of *Polaris*, **+0″.045.**

Table IV. Nyrén's Vertical-Circle Observations of *Polaris*, 1871–75.

t	w	n_1	v_1	n_2	v_2
1871-72-73		″	″	″	″
Nov. 18	5	—.05	+.01	.00	—.10
Apr. 5	3	.00	+.22	+.34	+.12
27	10	—.34	—.09	+.20	—.04
May 11	5	—.29	—.02	+.30	+.06
29	4	—.32	—.04	+.21	—.04
Aug. 15	2	—.17	+.10	+.23	+.02
26	3	—.09	+.16	+.13	—.07
Sept. 4	3	—.36	—.11	+.21	+.03
25	2	—.11	+.12	+.16	.00
Oct. 6	8	—.21	+.02	+.15	+.01
17	7	—.25	—.05	+.18	+.05
Nov. 16	5	—.13	+.04	+.11	+.01
Jan. 30	3	—.14	—.04	+.13	.00
1873		″	″	″	″
Feb. 24	5	+.02	+.11	+.22	+.06
Mar. 16	5	.00	+.09	+.18	—.01
25	8	—.21	—.11	+.13	—.07
31	4	—.23	—.13	+.31	+.10
Apr. 12	3	—.02	+.09	+.12	—.11
23	9	—.23	—.11	+.26	+.02
[*wnn*]. [*wvv*]				3.80	0.30
May 8	2	—.16	—.04	+.26	+.02
June 1	3	—.15	.00	+.23	—.01
10	5	—.31	—.14	+.24	.00
22	3	—.30	—.11	+.19	—.03
July 2	4	—.25	—.04	+.09	—.12
1874-75		″	″	″	″
Mar. 22	2	—.12	—.05	+.03	—.18
Apr. 7	2	—.21	—.16	+.14	—.09
22	2	—.08	—.05	.00	—.23
May 15	6	+.04	+.06	+.24	.00
26	4	+.05	+.07	+.30	+.06
30	6	—.12	—.09	+.25	+.01
July 9	6	—.10	+.01	+.25	+.01
Oct. 22	5	—.19	+.15	+.09	+.04
May 2	11	.00	+.02	+.36	+.12
24	3	+.18	+.15	+.14	—.11
June 24	4	+.10	+.05	+.25	+.03
July 7	1	+.09	+.05	+.13	—.08
[*wnn*]. [*wvv*]		6.22	1.34	4.03	0.47

For convenience, I give a summary of the results of the Vertical-Circle observations of *Polaris*, §§2, 4 and 5, with Nyrén's results for comparison.

	Present		Nyrén's	
	Aberration	Parallax	Aberration	Parallax
	″	″	″	″
Peters, 1842–44	20.510	+0.055	20.507	+0.071
Gyldén, 1863–70,	20.411	+0.046	20.469	+0.006
Nyrén, 1871–73.4,	20.515	+0.038	20.498	+0.031
" 1873.4–75.5,	20.508	+0.079	-	-

The next discussions to be presented will be those pertaining to the various series of Pulkowa prime-vertical observations.

THE PARALLAX OF β *CYGNI*,

By HAROLD JACOBY.

The collection of plates deposited at Columbia College by RUTHERFURD contains fifteen plates of β *Cygni*. Six of these were measured under RUTHERFURD's direction, and the results are contained in the sixth volume of the *Annals of the New York Academy of Sciences*. These results having indicated that β *Cygni* probably has a large parallax (see *Astr. Jour.*, no. 287), it has seemed desirable to examine the nine plates that were not measured by RUTHERFURD. Eight of these are in perfectly good condition; and I have accordingly measured them on the RUTHERFURD machine, using in general the method employed by RUTHERFURD, except that in measuring the western impressions, I have recentered the plate on the western impression of β *Cygni*. Each determination of distance depends upon six pointings on the central star (β *Cygni*), and six on the comparison-star. The plate was always rotated 180° in position-angle when three of the pointings on each star had been made, the remaining pointings being taken in the reversed position of the plate. This rotation through 180° was not made by the aid of the position-circle, but the line joining the star-images was always independently adjusted to parallelism with the slide of the microscope carrier. Position-angles were not measured.

As comparison-stars I have used the following:

No.	Mag.	Pos.-Ang.	Distance
		°	″
12	9.0	221	1683
27	8.0	45	1555
30	8.7	96	1312
11	8.0	266	1291

These stars give good parallax factors, and they are only about an inch from the center of the plate. The separate observations will be contributed to the New York Academy Annals; the means for each observation-date are given in the following table. The 1875 observations are the RUTHERFURD measures; those for 1876 are the new measures. The distances are given in divisions of the scale, equal to 28″.01. They are fully corrected, and reduced to 1876.0 by means of AUWERS's proper motion, which is —0″.026 in R.A., and —0″.013 in δ. It will be noticed that the distances are smaller for the new measures than for those made by RUTHERFURD. This is due to the fact that the glass scale of the measuring machine was adjusted by me to a position differing from that used by RUTHERFURD. By a remeasurement of one of the plates measured by RUTHERFURD, I have been able to satisfy myself upon this point. It is therefore evident that the parallax-determination cannot be influenced in the least, since all the distances are reduced to a uniform scale by the correction given in the last column but one. This correction is simply a proportional part of the quantity in the column "mean *minus* sum." It takes full account of variations of scale-value due to a varying distance of the plate from the lens in making the exposure, as well as those arising from a varying adjustment of the scale. The amount never exceeds 0.0014 or 0″.04.

OBSERVATIONAL DATA. STARS 12–27.

Date	No. of plates	Average Hour-Ang.	Temp.	Distance		Sum of distances	Mean *minus* sum	Diff. of distances	Correction	Corrected difference
				Star 12	Star 27					
		h m	°	″	″	″		″		″
1875 July 26	3	—0 13	76	60.0832	55.4944	115.5776	—.0309	4.5888	—.0012	4.5876
1875 Sept. 20	3	+2 8	60	.0565	.5158	.5723	—.0256	.5407	—.0010	.5397
1876 May 31	2	—2 47	60	.0551	.4562	.5113	+.0354	.5990	+.0014	.6004
1876 June 1	2	—3 43	60	.0548	.4587	.5135	+.0332	.5961	+.0013	.5974
1876 Oct. 24	1	+3 15	60	.0348	.5042	.5390	+.0077	.5306	+.0003	.5309
1876 Nov. 4	2	+2 38	55	.0221	.4931	.5152	+.0315	.5290	+.0013	.5303
					Adopted mean	115.5467			Assumed value	4.5600

OBSERVATIONAL DATA. STARS 30–11.

Date	No. of plates	Average Hour-Ang.	Temp.	Distance		Sum of distances	Mean *minus* sum	Diff. of distances	Correction	Corrected difference
				Star 30	Star 11					
		h m	°	″	″	″		″		″
1875 July 26	3	—0 13	76	47.8962	46.0879	93.9841	—.0135	1.8084	—.0003	1.8081
1875 Sept. 20	3	+2 8	60	.9264	.0692	.9956	—.0250	.8572	—.0005	.8567
1876 May 31	2	—2 47	60	.8602	.0874	.9476	+.0230	.7727	+.0005	.7732
1876 June 1	2	—3 43	60	.8638	.0875	.9513	+.0192	.7763	+.0004	.7768
1876 Oct. 24	2	+3 31	60	.8964	.0555	.9519	+.0187	.8409	+.0003	.8412
1876 Nov. 4	2	+2 38	55	.8964	.0196	.9459	+.0247	.8468	+.0005	.8473
					Adopted mean	93.9706			Assumed value	1.8100

The following observation-equations result from the above data. The quantity y is the correction required by the adopted assumed proper-motion effect; x is the error of the assumed value of the "difference of distances;" and π is the parallax. The weight is equal to the number of plates from which the equation is obtained. The last plate has received half weight, as the western impressions were not good, and could not be measured. On another plate the star 12 was too faint for accurate bisection. The absolute terms are expressed in units of the second decimal place, equivalent to 0″.2801.

Observation-Equations, Stars 12–27.

$$\begin{array}{llllll} 1.00x & -0.43y & -0.75\pi & +2.76 = 0 & \text{wt.} & = 3 \\ 1.00 & -0.28 & +0.95 & -2.03 = 0 & & = 3 \\ 1.00 & +0.42 & -1.83 & +4.04 = 0 & & = 2 \\ 1.00 & +0.42 & -1.82 & +3.74 = 0 & & = 2 \\ 1.00 & +0.82 & +1.68 & -2.91 = 0 & & = 1 \\ 1.00 & +0.85 & +1.82 & -2.97 = 0 & & = 1\tfrac{1}{2} \end{array}$$

Solution.

$$\pi = +2.043 \pm 0.138 = +0''.572 \pm 0''.039$$

Observation-Equations, Stars 30–11.

$$\begin{array}{llllll} 1.00x & -0.43y & -0.50\pi & -0.19 = 0 & \text{wt.} & = 3 \\ 1.00 & -0.28 & -1.83 & +4.67 = 0 & & = 3 \\ 1.00 & +0.42 & +1.22 & -3.68 = 0 & & = 2 \\ 1.00 & +0.42 & +1.20 & -3.32 = 0 & & = 2 \\ 1.00 & +0.82 & -1.91 & +3.12 = 0 & & = 2 \\ 1.00 & +0.85 & -1.82 & +3.73 = 0 & & = 1\tfrac{1}{2} \end{array}$$

Solution.

$$\pi = +2.419 \pm 0.185 = +0''.686 \pm 0''.052.$$

The mean by weight of the above determinations is:

Parallax of *β Cygni* = **+0″.61** ±0″.03,

the two values agreeing as well as might be expected from their probable errors. The discordance from the value indicated in *A.J.* 287 is not unexpectedly large, when we consider the circumstances under which the values have been obtained. The strongest objection that can be raised against the reality of the parallax arises from the fact that the observations corresponding to the maxima of parallactic effect were made at hour-angles of opposite sign. There can be no doubt that systematic error may be introduced by this undesirable arrangement of the observations. The question can not be settled absolutely until the result has been confirmed or disproved by independent observations made with a different instrument. But we can perhaps throw some light on the matter by a consideration of the *β Cygni* observations contained in vol. VI of the *Annals of the New York Academy*. In the following table the stars are, arranged: first, in the order of position-angle; and secondly, in the order of distance from β. Only those stars are used that were observed on six plates. The table gives the difference in distance from β, taken in the sense July 26 *minus* Sept. 20. The arrangement in the order of position-angle shows that there has been a displacement of β between the two dates. If this displacement were instrumental in its origin, we might expect the arrangement in order of distance to show an increase of the effect as the distances increase. If the displacement is parallactic, there ought to be no such increase. The evidence of the table is therefore favorable to the hypothesis of parallax.

Order Pos.-Ang.		Order Pos.-Ang.		Order of Dist.		Order of Dist.	
Star	July-Sept.	Star	July-Sept.	Star	July-Sept.	Star	July-Sept.
22	—.0134	16	+.0208	20	—.0068	38	—.0175
25	—.0113	8	+.0199	13	+.0325	23	+.0125
26	—.0103	12	+.0268	17	—.0104	9	+.0062
36	—.0250	11	+.0189	11	+.0189	16	+.0208
27	—.0215	6	+.0289	30	—.0302	8	+.0199
20	—.0068	2	+.0413	18	—.0067	26	—.0103
42	—.0207	13	+.0325	27	—.0215	36	—.0256
30	—.0302	3	+.0165	12	+.0268	3	+.0165
38	—.0175	9	+.0062	25	—.0113	35	—.0096
35	—.0096	17	—.0104	6	+.0289	2	+.0413
23	+.0125	18	—.0067	22	—.0134	42	—.0207

Columbia College Observatory, 1893 *Feb.* 23.

OBSERVATIONS OF COMET 1892 III (*HOLMES*),

MADE AT THE VASSAR COLLEGE OBSERVATORY,

BY MARY W. WHITNEY.

1893 Poughkeepsie M.T.	∗	No. Comp.	☄ — ∗		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
Feb. 3 $8^h\ 11^m\ 37^s$	1	7	$-0^m\ 6^s.23$	$-7'\ 39''.6$	$1^h\ 47^m\ 20^s.98$	$+33°\ 50'\ 42''.6$	9.613	0.401
4 6 51 12	1	6	+1 18.00	—5 39.9	1 48 45.19	+33 52 42.2	9.437	0.230
8 7 45 7	2	4	—0 8.88	—2 54.2	1 54 58.44	+33 58 33.7	9.589	9.367
16 8 10 12	3	2	—0 1.30	+7 18.9	2 7 38.85	+34 14 44.9	9.598	0.370

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 47 28.16	−0.95 −0.97	+33 58 14.0	+8.2 +8.1	Weisse's Bessel I. 1047
2	1 55 8.31	−0.99	+34 1 19.9	+8.0	Compared with Weisse's Bessel I. 1292
3	2 7 41.18	−1.03	+34 7 18.1	+7.9	Weisse's Bessel II, 110

Comet faint and diffused. On Feb. 16, it was seen with much difficulty, and the observation of that date is of comparatively little weight.

ASTRONOMICAL JOURNAL PRIZES.

The judges appointed by the Editor of the *Astronomical Journal* to decide the award of prizes offered through him as set forth in the Announcements in *A.J.*, 284. 288, desire to submit a short statement of some of the general considerations which will govern them in making, or withholding, the awards. In doing this they do not wish to be understood as prescribing methods, or as excluding from consideration forms of excellence not enumerated by them.

They think that these prizes are entitled to a response worthy of the spirit in which they are offered; and they wish to indicate, therefore, briefly and merely in amplification of the Announcement, somewhat of that which they would regard as a minimum of requirement to be considered in this connection, — and to do this as their justification in advance, in case they should feel obliged to withhold one or both of the awards. Confidently anticipating, however, a competition corresponding to the zeal which invites it, the judges hope to be able to make their awards to works having distinguishing, and perhaps novel, points of excellence, such as would be worthy of imitation hereafter.

Observations of Comets.

The allowance for optical qualities of the respective telescopes will be construed to refer chiefly to cases where, from the faintness of the comet or from its peculiar physical structure, the large telescope has a distinct advantage over the small one. The use of a micrometer especially adapted to the accurate observation of very faint comets would be held to redound to the credit of the observer inventing or applying it.

Relative freedom from systematic peculiarities of observation would be regarded as a mark of excellence even more important than the nominal or apparent precision in other respects; since it would be held to indicate the exercise of alert attention, through preliminary examinations and tests upon the peculiarities of the object to be observed, as well as upon sources of error likely to arise from a careless habit of observing.

In judging the individual precision of observations, freedom from large or abnormal errors would be of the first importance; and success in dealing with faint or difficult objects would be especially regarded.

Generally speaking, four or five observations in each month, for each comet during its visibility, would be considered a fair average quota for one observer, and any increase upon this number would not be thought very specially desirable. But this limitation would not be held to apply to objects of much more than ordinary interest, nor to those having a short period of visibility, nor to the opening and closing month of visibility.

The judges would regard substantial accuracy in the reductions, with freedom from mistakes, as far more meritorious than the greatest refinement in the application of corrections, accompanied with large mistakes.

Orbit-Computation.

It would be expected, as a matter of course, in the computation of a definitive orbit of a periodic comet, that the formulas would be correctly chosen and applied, and that the numerical work would be carried through with precision. Cases might arise in which there is opportunity, or necessity, for ingenuity in the use of mathematical devices, and such special ingenuity, if required, would be recognized.

But, in general, distinguishing excellence in such computations would be sought for in the skill and good judgement with which the observations were treated. The judges will, therefore, regard with special attention: —

1. The care exercised in revision of the published observations.

2. The good judgement evinced in searching out and evaluating systematic errors of the observations, and in exhibiting competent evidence of the reality of such errors, whenever their existence is assumed.

3. The completeness and soundness of the discussion for assignment of relative weights to the observations and to the successive normal places.

4. The ability shown in indicating not only the ordinary technical probable error, but also the probable limits of uncertainty in the adopted elements.

5. In the case of a comet which has undergone marked changes of physical aspect during the period of observation, the collation and discussion of notes and researches upon the physical appearance of the comet, with special reference

to the probable relation of the various series of observations to the supposed center of gravity.

Referring to the second and third points, the judges would regard with much interest the extension of the discussion to the work of the observers in question upon other comets suited to the required purpose.

Variable Stars.

With regard to the variable stars, the terms of the Announcement are so explicit as to need little addition, except that the forthcoming catalogue will especially provide data to guide the judicious selection of the objects which most need observation. Publication of provisional results should be made from time to time, giving for the series on each star, the number of the observations, the interval embraced by them, the time of each maximum or minimum, and the magnitude at that phase expressed as nearly as possible in the ordinary, historical scale of magnitude. Also brief and clear notes as to marked secondary phases or inflections of the light-curves, if any. Definitive reductions are of course not expected, since from the nature of the case these cannot be properly made for some years to come.

Asaph Hall.
S. C. Chandler.
Lewis Boss.

NOTE ON SAWYER'S NEW VARIABLE IN *AQUILA*,

By FRIEDRICH W. RISTENPART.

Since the star S.D. —5°4858 comes within the work of our meridian circle, — which is to observe all stars brighter than $8^M.0$ between the equator and 8° of S. declination three times in each position of the instrument, — I have examined the observing-books for remarks upon its brightness.

The star was observed, 1885 July 29, 30, 31, by Prof. Valentiner, and 1892 Aug. 18, 20, 29, by myself. On the first two dates in 1885, it was noted as 0.5 brighter than the star north 1^m preceding, which is —5°4848, given as $7^M.0$ in the S.D. Accepting this, we recorded —5°4858 as $6^M.5$. At the observation 1892 Aug. 18, I find the remark "ruddy."

The observations with the meridian circle have shown us that the estimates of magnitude in the S.D. are not always quite trustworthy, and by no means homogeneous in different hours of R.A.; so that the magnitude $8^M.0$ S.D. is very easy to observe with bright field, in some parts of the heavens, but in others rather difficult. Therefore small differences from the magnitudes assigned in S.D. are disregarded by us, and only the conspicuous ones noted. Moreover, in the crowded parts of the milky way, there is not time for devoting attention to the magnitudes. Thus the omission of any remark in August 1892 indicates that the star was not difficult to observe, and by no means fainter than $8^M.0$; so that the redness on August 18 must have been very decided.

The reobservation of the magnitudes in the S.D. between $7^M.0$ and $7^M.8$, announced by Sawyer in *A.J.* no. 290, will be awaited here with great interest. It will confirm many of our notes on differences of brightness; and where it does not confirm them, a variability of the star in question would be suspected.

Karlsruhe, Baden, 1893 *March* 15.

NEW ASTEROIDS.

Prof. Krueger has kindly communicated the photographic discovery by Mr. Charlois of the following asteroids:

		Nice M.T.	α	δ	Daily Motion
	M	h m	h m s	° ′	
1893 *K*	12.5	March 8 9 45.0	10 53 36	+ 6 13	—48ˢ in α, and 7′ northward.
*L**	9	9 9 3.0	10 8 48	— 0 43	—56 " 3 "
M	13	10 11 26	11 41 28	+ 4 35	—52 " 5 "
N	12	11 10 25	11 28 36	+14 6	—48 " 7 "
O	12	"	11 31 56	+15 43	—52 " 7 "
P	13	"	11 36 52	+11 49	—52 " 3 "

* Mr. Perrotin says "probably not no. 322."

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New Asteroids.

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OBSERVATIONS OF THE SOUTH POLAR CAP OF *MARS* AT THE OPPOSITION OF 1892.

By GEORGE C. COMSTOCK.

Between July 16 and Sept. 29 I measured the position-angle of the south polar cap of *Mars* with the 40 cm. equatorial telescope of the Washburn Observatory on forty nights, usually making two independent determinations of the position-angle on each night. These observations were necessarily made when the planet was at considerable distances from the meridian, since I was also engaged in observations of the planet with the meridian-circle, but care was taken that the position-angles should be measured on each evening at approximately equal hour-angles on opposite sides of the meridian. The magnifying powers employed ranged from 196 to 439 diameters.

The micrometer-thread was placed tangent to the disk of the planet, and rotated about the disk until the polar cap appeared to be symmetrically disposed about the point of tangency. Five settings of this kind, combined with a determination of the parallel from a neighboring star, constitute a single determination of the position-angle of the cap; but, in the earlier part of the work, fearing that the observations might be affected with systematic errors depending upon the position of the telescope east or west of the pier, I combined with each determination, telescope east, a similar determination, telescope west, until a sufficient number of observations had been accumulated to show that no sensible difference exists between these results when each series is reduced with a value of the parallel determined in the corresponding position of the telescope. On Aug. 31 and subsequent dates the observations were made in a single position of the telescope tube.

The following table contains the observed values of the position-angles, together with the corresponding residuals, v, furnished by the discussion given below.

Observed Position-Angles of the South Polar Cap.

Date	G.M.T.	Obs'd p	Red. to Aug. 3	ω	v	Remarks
1892	h m	°	°	°	°	
July 16	18 22	175.7	+2.3	356.2	+0.6	
16	20 26	176.6	2.3	26.4	—0.1	Poor seeing
17	18 38	175.1	2.2	351.2	+1.3	Poor
17	20 17	178.3	2.2	15.1	—1.8	Seeing fairly good
18	18 22	175.5	2.1	338.3	+0.9	Through clouds. Good
20	18 36	176.1	2.0	323.8	+0.2	Quite poor
20	20 6	177.7	2.0	345.7	—1.2	
21	18 10	174.8	1.8	308.5	+1.6	Fair
21	20 8	177.5	1.8	337.3	—0.8	Much poorer than the preceding
25	17 51	174.1	1.3	268.3	+2.6	Through clouds. Poor
25	19 50	177.5	1.3	297.3	—0.7	Seeing has improved
26	17 45	174.2	1.1	257.9	+2.7	Poor
26	19 44	179.5	1.1	286.9	—2.5	
29	17 7	176.0	0.7	222.1	+1.4	Through clouds. Faint
29	19 31	178.6	0.7	257.2	—1.3	
30	17 12	177.9	0.5	214.4	—0.3	Poor seeing
30	19 12	177.5	+0.5	243.7	—0.0	
Aug. 1	17 1	176.5	+0.2	194.0	+1.5	Seeing fair
1	19 6	180.7	+0.2	224.5	—2.9	
3	16 50	177.6	—0.1	173.6	+0.8	Very bad
3	19 2	178.8	—0.1	205.8	—0.6	Seeing has improved
1892	h m	°	°	°		
Aug. 4	16 49	177.0	—0.3	164.5	+1.8	
4	18 56	180.8	0.3	195.5	—2.3	
5	16 28	178.8	0.4	150.6	+0.2	Excellent
5	18 54	180.4	0.5	186.2	—1.6	Rather poor
6	16 49	178.9	0.6	146.8	+0.3	
6	19 2	181.0	0.6	179.3	—2.2	
7	16 15	179.5	0.8	129.7	+1.6	
7	18 47	181.8	0.8	166.8	—2.1	
8	17 30	179.0	1.0	139.1	+2.0	
10	16 16	180.6	1.3	103.4	+1.0	
10	18 43	180.8	1.3	139.2	+0.6	
11	16 21	179.9	1.4	95.7	+2.2	Cap begins to appear blurred on western edge of planet
11	18 27	181.4	1.4	126.4	+0.4	
12	16 9	181.1	1.6	83.9	+1.0	Through clouds. Good
12	18 16	182.6	1.6	114.8	—0.4	
14	16 12	181.2	1.9	66.9	+0.8	
14	18 11	183.5	1.9	95.9	—1.0	
15	15 53	180.7	2.0	53.4	+1.0	Seeing fairly good
15	18 6	184.3	2.0	85.8	—1.7	
16	17 50	184.1	2.2	73.2	—1.6	
17	18 20	184.0	2.3	71.4	—1.4	
18	15 21	178.8	—2.4	18.8	+1.6	Through light clouds. Obs. very easy and certain

Date	G.M.T.	Obs'd p	Red. to Aug. 3	ω	v	Remarks
1892	h m	°	°	°	°	
Aug. 18	17 58	182.7	—2.4	57.1	—0.4	
19	15 38	179.0	2.6	14.1	+1.4	
19	17 50	182.8	2.6	46.3	—0.8	
21	15 30	178.0	2.8	354.3	+1.6	
21	17 44	183.1	2.8	26.9	—1.8	
24	15 22	177.2	3.1	325.4	+1.4	Excellent seeing
24	17 51	181.4	3.1	1.8	—2.4	A deep notch in edge of cap in longitude 0°
25	15 20	177.5	3.2	316.0	+0.9	
25	17 28	181.8	3.2	347.2	—2.2	Very bad seeing
31	17 23	178.7	—3.5	291.8	—0.5	
Sept. 9	14 9	184.0	—3.5	162.5	+0.4	
11	15 21	183.6	3.4	161.6	+0.8	Haze. Planet very faint
14	13 58	184.0	3.2	113.8	+1.0	
14	14 4	187.0	3.2	115.2	—2.0	
15	12 49	183.1	3.1	87.7	+1.2	
15	14 1	184.2	—3.1	105.2	+0.5	

Date	G.M.T.	Obs'd p	Red. to Aug. 3	ω	v	Remarks
1892	h m	°	°	°	°	
Aug. 15	16 2	186.5	—3.1	134.7	—1.7	
16	13 59	183.5	3.0	95.5	+1.0	Poor seeing
16	15 58	186.1	3.0	124.6	—1.3	
17	13 47	180.5	2.9	83.3	+3.1	Very bad seeing
17	15 52	183.5	2.9	113.7	+1.2	
19	13 30	182.7	2.7	60.6	+0.0	
19	15 46	188.4	2.7	93.7	—4.3	
20	13 36	180.9	2.6	52.8	+1.3	
20	15 42	183.8	2.6	83.5	—0.2	
26	15 54	181.5	1.7	30.4	—1.6	
28	15 46	178.2	1.3	9.6	+0.2	
29	16 20	179.2	—1.1	8.5	—1.1	
Oct. 5	. .	. .	. .	. .	. .	Cap barely visible
8	. .	. .	. .	. .	. .	Seeing fair. Cap invisible
29	. .	. .	. .	. .	. .	Cap again visible

An inspection of the results of these measures will show the presence of a well marked tendency to obtain smaller values for the position-angles when *Mars* is observed east of the meridian than when west; the difference W.—E. increasing from +2°.4 in July to +2°.7 in August, and +3°.4 in September, although the latter number is by no means so well determined as the first two. The application of one-half of the mean difference, as a systematic correction to the observations, would have rendered them much more accordant, and perhaps have removed a real source of error from those nights on which observations were made on only one side of the meridian.

I have, however, preferred to use the uncorrected observations for a determination of the position of the rotation axis of the planet, trusting to the very approximate equality in the number of observations east and west to eliminate whatever error may be involved.

The notation and the formulas employed for the discussion of the observations are as follows:

π = Observed position-angle of the polar cap.
$P(\tau)$ = Position-angle of the axis of *Mars* at the instant τ.
ω and β = Areographical longitude and latitude of the center of the disk of *Mars*.
θ and λ = Areographical longitude and south polar distance of the center of the cap.
T = Aug. 3.0 Greenwich M.T.

$$p = \pi + \{P(T) - P(\tau)\}$$
$$P(T) = p + \lambda \sec\beta \sin\theta \cos\omega - \lambda \sec\beta \cos\theta \sin\omega$$

The quantities β, ω and $P(T) - P(\tau)$ have been derived from MARTH's ephemeris (*Month. Not. R.A.S.* March, 1892). For the actual reduction of the observations I have put

$$180° - p = 5\,n \qquad -\lambda \sec\beta \sin\theta = 5\,y$$
$$P(T) - 180° = 5\,x \qquad +\lambda \sec\beta \cos\theta = 5\,z$$

which furnishes as the observation-equation.

$$x + y \cos\omega + z \sin\omega + n = 0$$

The application of this type of equation to the discussion of any series of observations presupposes that the unknown quantities remain constant during the entire series, and the longer the series the more questionable does this assumption become. On the other hand it is practically impossible to derive values of λ and θ from observations extending over less than a fortnight or three weeks. It was my original purpose to close the observations at the end of August, and to discuss the entire series as a single set, but a provisional solution having caused me to suspect a considerable movement of the polar cap, I decided to recommence the observations in September, and continue them so long as they could be conveniently made, in order to confirm or disprove the suspected motion. During September the planet had become sensibly gibbous, but fortunately the position-angle of the cusps was such that the shadow at no time reached the cap, and since in the observations attention was concentrated upon those parts of the limb immediately adjacent to the cap, I have considered it permissible to neglect the gibbosity.

For the formation of the normal equations, I have divided the observations into three groups, as indicated in the tabulation, and have derived from these groups the following normal equations and values of the unknown quantities:

July 16 *to August* 6.

$$26.00\,x - 1.81\,y - 9.15\,z + 8.78 = 0$$
$$-1.81\,x + 16.75\,y - 0.09\,z - 1.07 = 0$$
$$-9.15\,x - 0.09\,y + 9.24\,z - 3.63 = 0$$

$$x = -0°.304 \qquad P(T) = 178°.48 \pm 0°.26 \qquad \beta = -13°.5$$
$$y = +0.032 \qquad \lambda \sec\beta \sin\theta = -0.16 \pm 0.26 \qquad \theta = 341.$$
$$z = +0.093 \qquad \lambda \sec\beta \cos\theta = +0.46 \pm 0.43 \qquad \lambda = 0.47$$
$$[vv] = 58°.16 \qquad 25[nn \cdot 3] = 58°.00 \qquad r_1 = \pm 1°.07$$

August 6 *to August* 31.

$$28.00\,x + 5.06\,y + 11.53\,z + 6.80 = 0$$
$$5.06\,x + 13.06\,y - 1.75\,z + 4.89 = 0$$
$$11.53\,x - 1.75\,y + 14.91\,z - 3.64 = 0$$

$$\begin{array}{lll} x = -0^\circ.465 & P(T) = 177^\circ.68 \pm 0^\circ.26 & \beta = -12^\circ.1 \\ y = -0.117 & \lambda \sec\beta \sin\theta = +0.58 \pm 0.31 & \theta = 11. \\ z = +0.591 & \lambda \sec\beta \cos\theta = +2.96 \pm 0.34 & \lambda = 2.95 \\ [vv] = 58^\circ.12 & 25[nn \cdot 3] = 58^\circ.25 & r_1 = \pm 1^\circ.02 \end{array}$$

September 9 to September 29.

$$\begin{array}{r} 18.00x - 0.61y + 13.28z - 2.32 = 0 \\ -0.64x + 6.55y - 1.16z + 2.82 = 0 \\ 13.28x - 1.16y + 11.41z - 2.72 = 0 \end{array}$$

$$\begin{array}{lll} x = -0^\circ.231 & P(T) = 178^\circ.08, & \beta = -13^\circ.5 \\ y = -0.395 - 0.110x, & \lambda \sec\beta \sin\theta = +1.79, & \theta = 36. \\ z = +0.198 - 1.175x, & \lambda \sec\beta \cos\theta = +2.45, & \lambda = 2.95 \\ [vv] = 50^\circ.10 & 25[nn \cdot 3] = 49^\circ.50 & r_1 = \pm 1^\circ.22 \end{array}$$

It is apparent that the last group of normal equations is inadequate for the determination of both x and z. I have therefore determined y and z as functions of x, and have derived from the equations the best value of x which they can afford, viz.: $-0^\circ.231$, but I have substituted in place of this value the mean of the values derived from the first two groups of equations, $x = -0^\circ.384$, in obtaining the definitive values of y and z. Despite this considerable change in the value of x the sum of the squares of the residuals exceeds $25[nn \cdot 3]$ by $0^\circ.60$ only.

The value of β has been assumed constant during the period covered by each group of normal equations, and the mean values given above have been adopted in deriving the values of λ.

Contemporaneously with the observations above discussed I made a series of determinations of the angular extent of the polar cap. Most of these determinations were made by placing the micrometer-thread tangent to the disk of the planet at the extreme limits of the cap. If the difference between the readings of the position-circle corresponding to the extremities of the cap be denoted by A, the angular extent of the cap will be given with sufficient accuracy by the equation:

$$E = A - \tfrac{1}{2}\beta^2 \sin A$$

where β denotes the areographical latitude of the center of the disk. In a few cases, designated in the following table by the letter M, the width of the spot was measured with the micrometer-screw, and the angular extent computed from the known semidiameter of the planet.

ANGULAR EXTENT OF THE SOUTH POLAR CAP.

1893	G.M.T.	E	M	1893	G.M.T.	E
	h	°			h	°
July 17	20	49.8	M	Aug. 18	16	33.5
20	20	38.0		24	18	31.2
20	20	47.3	M	31	17	27.9
26	19	37.0	M	Sept. 9	14	21.5
29	20	42.0		14	14	22.0
29	20	38.7	M	15	13	25.4
Aug. 5	18	44.2	M	16	14	20.3
10	16	37.0		19	13	21.6
12	16	38.0		20	14	20.1
15	15	35.9				

Madison, 1893 *March* 9.

Collecting from this table the mean values corresponding to the epochs of the quantities derived from the least-square solutions, there results the following comparison between the dimensions of the cap and the coordinates of its center, to which is added the adopted corrections to the position-angle of the axis of *Mars* given by MARTH's ephemeris.

1892	Diam. of Cap	λ	θ	Δ Ephem.
	°	°	°	°
July 26	44	0.47	341	−2.26
Aug. 18	35	2.95	11	−3.06
Sept. 19	22	2.95	36	−2.66

The difference between the coordinates of the center of the cap furnished by the July and August observations appears to me greater than can reasonably be explained by error in the determinations, and points to an unsymmetrical shrinking of the spot.

The only similar series of contemporary observations whose results are accessible to me are those of Prof. CAMPBELL (*A.J.* no. 282), and of Prof. HALL (*A.J.* no. 288). The former finds, for the correction to the position-angles of the axis of *Mars* given by MARTH's ephemeris, $-0^\circ.16$, and the latter $+1^\circ.24$, results which differ considerably from those given above. A comparison between nearly simultaneous observations of the three series shows that this difference is inherent in the observations, and does not arise from different treatment of the data. Since the three observers followed different methods of placing the micrometer-threads with respect to the polar cap, it appears probable that these differences correspond to the systematic errors affecting the methods employed.

The following measures of the diameter of the planet were made near the time of opposition.

Date	Eq. Diam.	Polar Diam.
	″	″
Aug. 5	26.06	25.19
6	25.80	25.36
7	26.25	25.67

The apparent excess of the equatorial over the polar diameter which is here indicated may be due to a systematic error depending upon the position-angle of the distance measured. Treating the disk as circular, and taking the mean of the six measures, they furnish as corrections to the values given by MARTH and in the *American Ephemeris*, respectively, $+0''.89$ and $-1''.07$. These corrections have been applied in the derivation of the angular extent of the polar cap from micrometer-measures of its width.

ON THE ELEMENTS AND LIGHT-VARIATION OF 6981 *U AQUILAE*,

BY PAUL S. YENDELL.

The variability of this star was discovered by SAWYER in 1886, and announced by him in this Journal, Vol. VII, p. 22. In a subsequent paper on page 87 of the same volume, he gives provisional elements and an approximation to a mean light-curve, together with his observed times of maxima and minima for 1886.

I have observations of the star for four seasons, 1888, 1890, 1891 and 1892. The results of the observations for 1888 have not heretofore been published, but now appear in the table of observed times given below; those for 1890 and 1891 have already been published in this Journal, Vol. X, p. 99, and Vol. XI, p. 87.

Maxima						Minima					
E.	Local M.T.	w	O—C	O—C′	Obs.	E	Local M.T.	w	O—C	O—C′	Obs.
0	1886 Sept. 19.88	1	+0.08	−0.07	S						
4	Oct. 17.97	1	+0.04	—0.08	"						
5	23.89	2	−1.08	—1.19	"	5	1886 Oct. 23.57	2	+1.10	+0.74	S
6	Nov. 1.00	2	±0.00	—0.11	"						
7	8.20	3	+0.17	+0.07	"	7	Nov. 6.06	2	+0.53	+0.18	"
8	15.11	2	+0.05	—0.05	"	8	13.00	1	+0.44	+0.09	"
9	22.43	3	+0.33	+0.24	"	9	19.81	2	+0.21	—0.13	"
10	29.62	2	+0.49	+0.41	"	10	26.84	2	+0.21	—0.12	"
11						11	Dec. 4.33	2	+0.67	+0.34	"
12	Dec. 13.11	1	—0.09	—0.16	"						
13	19.64	1	—0.59	—0.65	"	13	18.52	1	+0.79	+0.48	"
93	1888 July 4.30	4	—0.57	—0.10	Y						
94	12.00	3	+0.10	+0.58	"	94	1888 July 7.25	4	—2.45	—1.92	Y
95	18.33	2	—0.60	—0.12	"	95	15.60	4	—1.13	—0.60	"
96	25.40	1	—0.56	—0.08	"						
100	Aug. 22.83	1	—0.27	+0.25	"						
101	29.93	2	—0.20	+0.32	"	101	Aug. 26.30	3	—1.33	—1.06	"
102	Sept. 5.36	2	—0.80	—0.28	"						
198	1890 July 12.20	4	—1.13	+0.01	"						
199	19.40	3	—0.97	+0.19	"						
200						200	1890 July 24.00	2	—0.90	+0.01	"
202						202	Aug. 7.00	3	—0.96	—0.04	"
203	Aug. 15.40	4	—2.10	—0.92	"						
205	31.05	3	—0.52	+0.68	"						
206	Sept. 8.16	2	+0.56	+1.76	"	206	Sept. 4.30	4	—0.80	+0.15	"
208						208	18.50	1	—0.87	+0.10	"
209	29.80	1	+1.10	+2.32	"						
210	Oct. 2.51	1	—3.22	—1.99	"						
211	11.39	1	—1.37	—0.14	"						
249	1891 July 4.92	4	—2.10	—0.61	"						
250	12.30	4	−1.75	—0.26	"	250	1891 July 9.30	4	−2.25	—1.01	"
252	27.20	3	—0.92	+0.59	"						
253	Aug. 3.86	2	—0.29	+1.22	"	253	31.40	3	—1.25	+0.01	"
254	11.06	3	—0.12	+1.39	"						
256	23.91	2	—1.34	+0.19	"						
258	Sept. 7.30	3	—0.41	+1.13	"	258	Sept. 3.60	4	—2.21	—0.92	"
260	21.25	3	—1.13	+0.42	"						
261	28.66	2	—0.75	+0.81	"						
262	Oct. 4.72	2	—1.72	—0.16	"	262	Oct. 2.40	1	—1.94	—0.23	"
264	19.98	1	—0.53	+1.05	"						
303	1892 July 18.50	4	—2.30	—0.46	"	303	1892 July 16.50	2	—1.80	—0.21	"
304	25.40	2	—2.43	—0.59	"	304	24.30	4	—1.03	+0.56	"
307	Aug. 15.50	4	—2.43	—0.57	"	307	Aug. 13.40	2	—2.03	—0.42	"
308	23.40	4	—1.57	+0.31	"						
309	29.30	1	—2.70	—0.82	"						
311	Sept. 12.60	3	—2.47	—0.57	"	311	Sept. 10.30	4	—2.27	—0.62	"
313	26.80	4	—2.33	—0.43	"						
315	Oct. 10.10	2	—3.10	—1.18	"						
316	19.30	1	—0.93	+0.99	"						

The observations for 1892 are thirty-nine in number, and extend from July 16 to Nov. 6; they yield eight maxima and four minima. A comparison of the observed times of maximum with Chandler's catalogue elements, at once indicated that too long a period had been assigned to the star, which indication was confirmed by the residuals shown by the observed maxima of the three previous years.

A careful re-reduction of the whole four years' observations, about 130 in number, afforded forty-one maxima and fifteen minima; these, with those of Sawyer already mentioned, making a list of forty-nine maxima and twenty-two minima, appear in the table above; the residuals from comparison with Chandler's elements are given in the columns O—C; those from the elements derived from these residuals, in the columns O—C′.

The error in the numeration of the Epochs of maxima and minima, in Sawyer's published observations, to which my attention has been called by Mr. Sawyer, has been corrected in this table.

Owing to the fewness of the observed minima, no use of them has been made in the determination of new elements, the maxima alone having been employed; a discussion of the residuals from these, given above in the column O—C, gives the following corrections:

To the Epoch $+0^{d}.1461 \quad \pm 0^{d}.035$
To the Period $-0^{d}.006552 \quad \pm 0^{d}.00167$

The elements obtained by applying these corrections to those of Chandler with which the original comparisons were made, are

Max., 1886 Sept. 20.1461 Greenwich M.T. $+7^{d}.026448\,E$

These appear to be the best at present attainable.

The comparison-stars used are those of Sawyer, given by him in his first paper, already alluded to; the light-scale, from my four years' observations, is as follows:

$a = 23^{\text{st.}}.8$ | $e = 11^{\text{st.}}.5$
$b = 18.3$ | $f = 8.0$
$c = 18.3$ | $g = 5.0$
$d = 14.3$

The value of the star b is of little weight, being deduced from only two comparisons.

By the use of this light-scale and the elements above given, a mean light-curve was constructed from the entire body of the observations; this gives a range from $8^{\text{st.}}.5$ to $17^{\text{st.}}.2$, or from $7^{\text{M}}.05$ to $6^{\text{M}}.40$; the extreme observed magnitudes are $7^{\text{M}}.23$ and $6^{\text{M}}.35$.

The characteristics of the star's light-variation are: a rapid and uniform rise, a well-marked maximum phase, and a decline about as rapid as the increase until one and a quarter days after the maximum; at this point a marked slackening in the rate of decline begins to show, which increases until about two and three-quarters days after maximum, at which time the decrease seems to have stopped, and the star's light to remain unchanged for a quarter of a day; after the fourth day, the decline again becomes rapid, and the minimum is as sharply marked as the maximum. The minimum precedes the maximum 2.25 days.

The readings from the mean curve are as follows: .

Before Max.		After Max.			
d	st.	d	st.	d	st.
−2.25	8.50	+0.25	17.00	+2.75	12.50
2.00	8.60	0.50	16.35	3.00	12.50
1.75	9.50	0.75	15.50	3.25	12.40
1.50	10.60	1.00	14.70	3.50	12.30
1.25	12.00	1.25	14.00	3.75	12.00
1.00	13.65	1.50	13.50	4.00	11.20
0.75	15.20	1.75	13.20	4.25	10.00
0.50	16.25	2.00	12.90	4.50	9.15
—0.25	17.00	2.25	12.70	4.75	8.55
±0.00	17.20	+2.50	12.55	+4.776	8.50

1893 *February* 25.

CONTRIBUTIONS TO THE KNOWLEDGE OF THE VARIABLE STARS,

By S. C. CHANDLER.

VII.

Since the publication of the theory of the inequalities of *Algol*, vol. XII, I have ascertained that those of two other stars of this type are apparently of the same character. Below is a brief statement of the results, and some apparently legitimate and interesting conclusions therefrom.

320. *U Cephei.*

In my paper on this star, *A.J.* IX, 49, it was shown, among other things, that the period has increased since its discovery, and that the rate of the change is not uniform. It is now manifest that this increase has stopped, and that a decrease has set in. The nature of the change can be seen by means of the column "Observed Inequality" below, which gives the deviations, O—C, of the various normal epochs, from the first two terms of the definitive elements,

$$1880 \text{ June } 23^{d}\ 9^{h}\ 28^{m}.0 \text{ (Gr. M.T.)}$$
$$+\ 2^{d}\ 11^{h}\ 49^{m}\ 38^{s}.25\,E + 95^{m}\sin(0^{\circ}.08\,E + 283^{\circ})$$

Approx. Date	E	Inequality Obs.	Inequality Comp.	O—C
		m	m	m
1828.4	—7636	+43.7:	+50.5	—6.8:
1881.1	+ 92	—89.2	—89.1	—0.1
1882.1	239	—78.7	—80.5	+1.8
1882.7	324	—79.0	—73.9	—5.1
1883.6	453	—64.8	—62.0	—2.8
1884.2	548	—53.0	—52.0	—1.0
1887.9	1088	+17.5	+17.1	+0.4
1888.3	+1141	+21.9	+23.4	—1.5

Approx. Date	E	Inequality Obs.	Inequality Comp.	O—C
		m	m	m
1888.9	+1233	+36.7	+38.7	—2.0
1889.9	1384	+53.7	+52.7	+1.0
1890.9	1525	+68.2	+67.2	+1.0
1892.2	1719	+82.6	+82.7	—0.1
1893.3	+1861	+89.1	+90.5	—1.2

These normal epochs were formed from the table of observed minima, *l.c.*, with the addition of those published by Dunér and Yendell since that time. The latter has also kindly furnished me with the original data of his recent observations, so that I could reduce them homogeneously by the method employed for Wilsing's and my own.

The column "Computed Inequality" gives the periodical term of the above elements. The last column shows how well the elements represent the observations. The length of the cycle, and the amplitude of the variation of the period are yet somewhat uncertain, but the observations of the next year or two will doubtless fix these with considerable precision.

If we interpret the elements by the theory advanced in the case of *Algol*, the time of revolution of *U Cephei* and its occulting companion around the assumed distant third companion occupies 4500 periods of the light-variation, or about 30.7 years. The radius of the orbit, assumed circular, is about 11.5 cosec i, measured in the earth-sun distance unit. Hence its size must be somewhat larger than that of *Saturn*, as a minimum value, corresponding to the case of $i = 90°$, *i.e.*, the observer being in its plane.

Unfortunately we have not enough catalogue-places to detect irregularity of proper motion, which must exist in this star if the assumed theory be correct. I find it only in Fedorenko's Lalande, Schwerd, Carrington and the Radcliffe annual volumes, as follows:

Catalogue No.	Epoch	Place reduced to 1875.0	
		h m s	° ′ ″
Fedorenko 145,	1790	0 51 16.34	+81 12 4.4
Schwerd 47,	1828.2	16.84	2.9
Carrington 130,	1855	17.84	4.4
Radcliffe	1880.9	17.20	3.3
"	1881.6	17.25	3.5
"	1882.5	17.36	2.9

No systematic corrections have been here applied. Their determination would be somewhat laborious and uncertain for a star so near the pole, and, for the present, unnecessary and premature. They must be small in any case, within the range of accidental error. Thus, Fedorenko reduced by means of Bradley and Bessel, the latter being founded on Argelander's Åbo catalogue. Schwerd's right-ascensions also rest indirectly on Åbo, and the corrections of his declinations are very small. Carrington rests on fundamental star-places corresponding closely to Wolfers.

From the above data we may assume the annual proper motion of *U Cephei* to be $+0^s.013$ and $0''.00$; thus, in great-circle arc, $0''.030$ in the direction of 90° position-angle.

Now by the assumed theory it would seem that the present orbital motion on the face of the sky must be a quantity easily measurable in a comparatively short time, unless the parallax is excessively small. Assuming a parallax of $0''.05$, we have for the radius of orbital motion, $0''.575$. Since, by the nature of the observed variation in the period of light-minima, the star is now near apogee, its present orbital motion on the sky is $0''.12$ annually, under these conditions, whatever the inclination of the orbit or the position-angle of the node. Combined with the average annual proper motion, the resultant is within the limits $0''.09$ and $0''.15$ annually. Thus the heliometer, or even the filar micrometer, could settle the question in a year or two at least, unless the parallax is much smaller than $0''.05$.

On the same assumptions, the motion in the line of sight, which is now nearly nothing, will in eight years increase to seven miles a second. Possibly by that time sufficiently powerful optical means may be brought to bear to determine this element by Vogel's spectrographic method.

6189. *U Ophiuchi.*

A full investigation was given, (*A.J.* VII, 129, 137), of all the observations of this star, up to 1886 inclusive. Since that time the shortening of the period there established has first diminished, then ceased; and at present there are symptoms of increase. The following table of normal epochs is the same as that on p. 132, *l.c.*, with the addition of others, similarly formed from 28 minima since observed by Yendell, Dunér, Sawyer and myself. The column "Observed Inequality" gives the deviations from the first two terms of the definitive elements.

$$1881 \text{ July } 17^d\ 14^h\ 45^m.0 (\text{Gr. M.T.}) + 20^h\ 7^m\ 42^s.56\,E + 80^m \sin(0°.0225\,E+140°)$$

Approx. Date	E	Inequality Obs.	Inequality Comp.	O—C	Obs.
		m	m	m	
1863.5	—7885	—141.3 : :	—58.6	—82.7 : :	Schj.
1871.8	—4267	+ 56.3 : :	+55.6	+ 0.7 : :	G
1881.8	+ 120	+ 38.6	+48.6	—10.0	S
1882.3	350	+ 42.4 :	+42.5	— 0.1 :	S
1882.5	416	+ 45.6	+40.8	+ 4.8	C
1882.6	451	+ 20.6 :	+39.8	—19.2 :	Schm.
1882.6	457	+ 38.7	+39.7	— 1.0	S
1882.6	479	+ 38.4	+39.1	— 0.7	C
1882.7	517	+ 33.6	+38.0	— 4.4	C
1882.7	517	+ 42.2	+38.0	+ 4.2	S
1883.5	838	+ 34.9	+28.9	+ 6.0	C
1883.5	839	+ 26.1	+28.9	— 2.8	S
1883.6	888	+ 26.4	+27.4	— 1.0	C
1883.6	891	+ 19.7	+27.3	— 7.6	S
1883.7	914	+ 33.5	+26.6	+ 6.9	C
1883.7	930	+ 25.4	+26.1	— 0.7	S
1884.6	1328	+ 28.3	+14 0	+14.3	S
1885.6	1769	+ 3.9	+ 0.3	+ 3.6	S
1886.6	2218	+ 3.8	—13.8	+17.6	S
1887.8	2719	— 28.4	—28.9	+ 0.5	C
1888.5	3051	— 35.4	—38.3	+ 2.9	S
1889.5	3472	— 54.4	—49.4	— 5.0	Y
1889.6	3515	— 43.5	—50.4	+ 6.9	S
1890.3	+3794	— 76.4 :	—56.9	—19.5 :	D

Approx. Date	E	Inequality Obs.	Inequality Comp.	O—C	Obs.
		m	m	m	
1890.6	+3920	— 41.2 :	—69.7	+28.5 :	Y
1891.6	4393	— 70.8	—68.5	— 2.3	Y
1891.7	4420	— 68.1 :	—68.9	+ 0.8 :	S
1892.4	+4762	— 74.2	—73.7	— 0.5	D

The first epoch, Schjellerup's, was merely a rude one, and the deviation is entirely within the range of its possible error. The remainder are satisfactory. The coefficients of the elements are decidedly more uncertain than in the case of *U Cephei*, but it is tolerably certain that the inequality is completed in about 16000 periods of the light-minima, or 37 years, with perhaps three or four years possible error.

The data for the place of the star are given in the following table.

Authority	Obs.	Epoch	1875.0		Syst.	Corr.	Observed		Computed	
			a	δ			Δa	$\Delta\delta$	Δa	$\Delta\delta$
			s	″	s	″	s	″	s	″
Lalande	1	1797.4	11.17	9.0	+0.29	—1.9	+0.075	—0 28	–	–
Bessel	1	1822.5	11.61	7.4	— .18	+1.9	+ .125	+2 29	–	–
Santini	4	1839.0	11.23	5.1	+ .05	+1.2	— .035	—0.47	+0.039	—0.49
Pulkowa Mer. C.	4	1845.9	11.24	5.9	+ .02	+0.1	— .028	— .66	— .029	— .18
Lamont (See 1)	2	1847.5	11.17	7.1	+ .03	—0.4	— .085	+ .07	— .040	— .04
Klinkerf (Schur.)	1	1862.5	11.23	7.9	— .03	—1.0	— .055	+ .49	+ .017	+ .29
Schjellerup	1	1863.5	11.22	7.4	+ .08	—0.3	+ .047	+ .70	+ .026	+ .21
Grant (1)	2–3	{1870.0 1872.7}	11.28	6.0	+ .02	—0.3	+ .060	— .56	+ .060	— .46
Paris. Merid. Circ.	1	1870.5	11.15	6.1	+ .12	—0.4	+ .031	— .29	+ .059	— .35
Rogers (1213)	6	1878.5	11.28	6.0	— .02	+0.1	+ .037	— .07	+ .005	— .11
Greenwich	3	1880.4	11.16	5.3	+ .03	+0.2	— .029	— .64	— .014	— .30
Boss	3	1880.9	11.29	6.2	—0.02	0.0	+0.052	+0.07	—0.020	—0.25

Columns 4 and 5 gives the catalogue-places, reduced to 1875.0. Columns 6 and 7 are the corrections to reduce to the system of the *Fundamental Catalog*. They were determined in the same way as for *Algol*, using 12 *Hauptsterne* within $1^h\ 30^m$ and 5°, and also, for the reduction of Lalande's and Bessel's zones, all of Bradley's stars therein contained, between +1° and +3°. The latter were also used for other authorities. We thus find the place and proper motion,

$$\alpha = 17^h\ 10^m\ 11^s.230 \quad -0^s.0020(t-1875)$$
$$\delta = +1^\circ.21\ 6''.22 \quad -0''.015\ (t-1875)$$

having regard to weights. These give the deviations $\Delta\alpha$ and $\Delta\delta$ in columns 8 and 9. While these are in general not greater than the errors of observation, they have a curious and possibly significant feature; namely, a systematic tendency not inconsistent with an irregularity of 36 years cycle, which the proper motion of the star ought to have, if the theory as to the variations of the light-periods of this class of stars is correct. This is evident by comparison with the last two columns, which give the values of

$$\Delta\alpha = 0^s.06\ \sin(t-1861)10^\circ \quad , \quad \Delta\delta = 0''.5\ \sin(t-1848)10^\circ$$

These are the equations for an apparent ellipse with a major axis of 1″.95, and a minor axis of 0″.7, the position-angle of the former being 115°. Assuming for the moment that it is real, and combining it with the far more definite information derived from the light-minima, we have an annual parallax of 0″.10, and an orbit something like this:

Period, 36 years
Passage of ☊, 1867
☊ = 97°
$i = 112^\circ$
$a = 10.0$

assuming it to be circular. This guess at the orbit has, it is true, a very slight foundation. If, possibly, it be approximately true, the present orbital motion of the star is at the rate of about 0″.10 annually, in the direction of 90° position-angle, whereas the mean proper motion, above given, is 0″.034 annually, in the direction of 223°. The fact of the existence of this or any comparable difference could certainly be settled micrometrically within two or three years.

Cambridge, 1893 *April* 2.

HERSCHEL'S ESTIMATES OF BRIGHTNESS OF NEBULAS EXPRESSED IN MAGNITUDES,

By ORMOND STONE.

In the following table the first column gives the brightness as designated in Herschel's General Catalogue; the second gives the mean of the corresponding magnitudes estimated by the different observers with the 26-inch refractor of the Leander McCormick Observatory, using a magnifying power of 175, and correcting for personal equation; the third gives the number of comparisons.

H.G.C.	L.M.Obs.	No.Comp.	H.G.C.	L.M.Obs.	No.Comp.
vB	12.0	13	*pF*	13.8	70
B	12.9	19	*cF*	14.3	8
cB	13.0	9	*F*	14.0	17
pB	13.3	99	*vF*	14.5	7

OBSERVATIONS OF COMET *f* 1892 (*HOLMES*),

MADE AT THE DUDLEY OBSERVATORY, ALBANY,

BY LEWIS BOSS.

1892–3 Albany M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
Dec. 9 $9^h\,42^m\,3^s$	1	21 , 9	$+0^m\,36^s.47$	$+2'\,9''.0$	$0^h\,46^m\,3^s.78$	$+35^\circ\,18'\,9''.1$	9.466	0.235
By W. O. Lay.								
Jan. 19 9 19 30	2	24 , 8	+1 13.31	+1 27.93	1 26 0.61	+33 38 44.5	9.6696	0.527
21 6 45 52	2	21 , 7	+3 45.82	+1 51.2	1 28 33.04	+33 39 7.9	9.2875	0.210

Mean Places for 1892.0 and 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	$0^h\,45^m\,21^s.60$	$+2^s.71$	$+35^\circ\,15'\,31''.9$	$+28''.2$	A.G. Leiden (2 obs.), Paris (2 obs.)
2	1 24 48.13	$\left\{\begin{matrix}-0.86\\-0.91\end{matrix}\right\}$	+33 37 18.2	— 1.6	Leiden (4 obs.) Paris, Lal. and Bessel (1 obs.)

NOTE. In my observation of Dec. 15 (*A.J.* 285), $\Delta\alpha$ for ☄ — * should be $-1^m\,26^s.65$.

NEW ASTEROIDS.

Through Professor KRUEGER's courtesy, we have notice of eight more small planets, found photographically, the first and last by Dr. WOLF, and the others by Mr. CHARLOIS.

				α	δ	Daily Motion
1893 *Q*	12^M	March 16	$12^h\,0^m$ Greenw. M.T.	$11^h\,11^m\,24^s$	$+\,8^\circ\,52'$	-40^s in α, and 5′ northward.
R	11	17	11 21 Nice M.T.	12 19 16	+ 4 38	-56^s " 4′ "
S	12	17	12 30 " "	10 50 16	+16 50	-44^s " 2′ "
T	12	19	10 55 " "	11 52 52	+11 29	-52^s " 5′ "
U	13	19	10 55 " "	12 1 12	+14 20	-56^s " 8′ "
V	13	21	10 40 " "	12 8 52	— 2 9	-52^s " 6′ "
W	12	21	10 40 " "	12 20 36	— 7 25	-52^s " 2′ "
X	$12\frac{1}{2}$	21	12 0 Heidelberg M.T.	12 24 32	— 0 43	-40^s " 5′ "

The asteroids of 1892 from *O* onward have received numbers as follows:

1892 *O*	(CHARLOIS, Nov. 23)	= no. 345	1892 *S*	(CHARLOIS, Dec. 8)	not numbered
P	(" " 25)	= " 346	*T*	(" " 9)	= no. 349
Q	(" " 28)	= " 347	*U*	(" " 14)	= " 350
R	(" " 28)	= " 348	*V*	(WOLF, " 16)	= " 351

Mr. CHARLOIS has assigned names, as below, to four of those discovered by him.

314	1891 Sept. 1,	*Rosalia*	317	1891 Sept. 11,	*Roxana*
316	Sept. 8,	*Goberta*	349	1892 Dec. 9,	*Dembowska*

CORRIGENDUM.

Vol. XII, p. 185, Aug. 28, *for* 270°.26 *put* 275°.24; and *for* 80″.21 *put* 79″.89

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OBSERVATIONS AND PERIODS OF SOME SOUTHERN VARIABLES.

BY ALEXANDER W. ROBERTS.

L_2 Puppis.

$\alpha = 7^h\ 9^m\ 53^s\ ,\ \delta = -44°\ 26'.7\ (1880.0)$

In computing the elements of *L_2 Puppis* the following dates of maxima have been used.

Epoch	Observed Max.	Julian Day	Observer	O—C d
—56	1872 Mar. 29	2 404 882	Gould	+ 5.8
55	Aug. 10	5 016	"	+ 2.6
51	1874 Feb. 8	5 563	"	+ 0.8
50	June 25	5 700	"	+ 0.6
19	1886 Jan. 20	9 927	Williams	—25.9
5	1891 May 4	2 411 857	Roberts	—16.9
3	1892 Feb. 27	2 156	"	+ 7.7
2	July 19	2 299	"	+13.5
— 1	Dec. 1	2 434	"	+11.3

Giving equal weights to these, we find

$p = 137^d.21 \qquad E = 2\,412\,559^d.9 = 1893$ April 5.9

with the discordances given in the column O—C above.

The period $136^d.05$ proposed by Mr. STANLEY WILLIAMS, with the epoch of maximum brightness 1878 March 16, does not satisfy later measures, but gives the discordances,

Epoch	O—C d
—19	+10.0
5	+35.3
3	+62.2
2	+69.1
— 1	+68.0

The light-curve is very irregular; none of the four curves, plotted down from the Lovedale measures, corresponding markedly with one another.

R Carinae.

$\alpha = 9^h\ 27^m\ 35^s\ ,\ \delta = -56°\ 30'.3\ (1880.0)$

In computing the period of this variable the following measures were used: (1) two measures made at Melbourne by Mr. ELLERY in 1867; (2) four maxima observed at Cordoba (*U.A.* 251); (3) the exceedingly valuable observations made by Mr. TEBBUTT from 1880 onwards; (4) the observations made at Lovedale from 1891 onwards.

(1) *Melbourne Measures.* Mr. ELLERY found the star $6\frac{1}{2}$ mag. on March 31, and 6.0 mag. on April 3, 1867. An examination of recorded measures indicates that *R Carinae* takes, on an average, twenty days to pass from $6^M.5$ to a maximum. The two observations would therefore give a maximum on 1867 April 20. In the computations weight-unity is given to this date.

(2) *Cordoba Measures.* The dates of maxima in the *Uranometria Argentina* are 1871 July 17, 1872 June 10, 1873 April 12, and 1874 March 4. To each of these a weight 3 is given.

(3) *Windsor Measures.* In order to obtain the dates of maxima and their relative values with as much accuracy as possible, all the full and very valuable series of observations made by Mr. TEBBUTT were plotted down, and light-curves drawn. With some curves no difficulty was experienced in readily determining the date of maximum brightness; with others this determination was not so easy. For instance, in May 1884, April 1885, January 1886, December 1886, and April 1890, the time of maximum is well marked; while for others, such as those of September 1882 and July 1883, as well as those at Lovedale in January 1892, and November 1892, there is no distinct maximum point.

With curves of the second class I have taken as the date of maximum brightness, the point where the star ceased to increase in brightness, that is, the intersection of the ascending curve and the almost horizontal line passing through the points of maxima. Eleven maxima have been obtained from the Windsor measures as given in the table below.

(4) *Lovedale Measures.* The two dates given by the Lovedale measures are 1892 January 1, weight 3, and 1892 November 3, weight 3.

The 18 dates mentioned give the table of maxima as follows, assuming 1893 September 21 as the principal epoch of maximum, and a period of 311 days.

Epoch	Obs'd Max.	wt.	C—O d	Epoch	Obs'd Max.	wt.	C—O d
—31	1867 Apr. 20	1	+10	—11	1884 May 24	2	—14
26	1871 July 17	3	+16	10	1885 Apr. 5	2	—19
25	1872 June 10	3	— 2	9	1886 Jan. 27	3	— 5
24	1873 Apr. 12	3	+ 3	8	Dec. 8	2	— 9
23	1874 Mar. 4	3	—12	7	1887 Oct. 13	1	— 7
15	1880 Dec. 16	4	— 3	5	1889 June 23	3	— 1
14	1881 Oct. 13	3	+ [illegible]	4	1890 Apr. 13	3	+13
13	1882 Aug. 23	3	+ 4	2	1892 Jan. 1	3	+ 7
—12	1883 July 3	3	+ 1	— 1	Nov. 3	3	+11

A solution of the resultant equations gives

$$\Delta p = -0^d.02 \qquad \Delta E = -0^d.72$$

The corrected elements of *R Carinae* are therefore

Period $310^d.98$ Epoch of maximum 1893 Sept. 20.28

A computation taking equal magnitudes before and after maxima, yields a period of $310^d.6$, but as the number of observations used extend over considerably fewer years than the series given above, it is entitled to less weight. It indicates, however, that the period of *R Carinae* hitherto given is too great.

R Muscae.

$\alpha = 12^h\ 34^m\ 46^s$, $\delta = -68° 44'.9$ (1880.0).

The observations taken at Lovedale from May 1891 to January 1893, were collected in groups of 30 days, and then the observations in each group were reduced to a mean curve, the period used in reducing being $0^d.8823$. When the number of observations in any group was less than four no mean curve was constructed. The dates of maxima and minima obtained, the number of observations in each group, as well as the probable weight of each set, are given in the following table.

P	Maxima	Minima	No. obs'ns in set	wt.
—20	1891 May 20.45	–	7	1
18	July 19.50	1891 July 19.20	34	3
17	Aug. 18.45	Aug. 18.16	5	1
16	Sept. 17.56	Sept. 17.26	4	1
13	Dec. 16.48	Dec. 16.20	5	1
12	1892 Jan. 15.55	1892 Jan. 15.27	6	1
9	Apr. 14.46	Apr. 14.16	13	2
8	May 14.19	May 14.20	11	2
7	June 13.47	June 13.22	16	2
6	July 13.48	July 13.22	22	3
5	Aug. 12.48	Aug. 12.19	18	3
4	Sept. 11.50	Sept. 11.20	7	1
3	Oct. 11.50	Oct. 11.20	6	1
2	Nov. 10.55	Nov. 10.27	9	1
— 1	Dec. 10.57	Dec. 10.30	4	1
0	1893 Jan. 9.54	1893 Jan. 9.22	11	3

Assuming the approximate values

E = Epoch for principal maximum = 1893 Jan. 9.50
" " " minimum = Jan. 9.22
P = Time required for 34 periods = $30^d.0$

we have the data

P	Maxima, O—C	Minima, O—C	wt.
	d	d	
—20	+0.05	–	1
18	.00	+0.02	3
17	+ .05	+ .06	1
16	— .06	— .04	1
13	+ .02	+ .02	1
12	— .05	— .05	1
9	+ .04	+ .06	2
8	+ .01	+ .02	2
7	+ .03	.00	2
6	+ .02	.00	3
5	+ .02	+ .03	3
4	.00	+ .02	1
3	.00	+ .02	1
2	— .05	— .05	1
—1	— .07	— .08	1
0	—0.04	0.00	3

From these I deduced the values for the maxima

$$E = 1893 \text{ Jan. } 9.515 \pm 0^d.011 \qquad P = 30^d.002 \pm 0^d.001$$

and for the minima

$$1893 \text{ Jan. } 9.224 \pm 0^d.012 \qquad 30^d.0015 \pm 0^d.001$$

With these elements the following residuals have been computed:

P	Obs'd Maxima	O—C	Obs'd Minima	O—C
		d		d
—20	1891 May 20.45	—0.025	–	–
18	July 19.50	+ .021	July 19.20	+0.003
17	Aug. 18.45	— .031	Aug. 18.16	— .038
16	Sept. 17.56	+ .077	Sept. 17.26	+ .060
13	Dec. 16.48	— .009	Dec. 16.20	— .004
12	1892 Jan. 15.55	+ .059	Jan. 15.27	+ .064
9	Apr. 14.46	— .037	Apr. 14.16	— .050
8	May 14.49	— .009	May 14.20	— .012
7	June 13.47	— .031	June 13.22	+ .007
6	July 13.48	— .023	July 13.22	+ .005
5	Aug. 12.48	— .025	Aug. 12.19	— .026
4	Sept. 11.50	— .007	Sept. 11.20	— .018
3	Oct. 11.50	— .009	Oct. 11.20	— .019
2	Nov. 10.55	+ .039	Nov. 10.27	+ .049
— 1	Dec. 10.57	+ .057	Dec. 10.30	+ .078
0	1893 Jan. 9.54	+0.025	Jan. 9.22	—0.004

We may thus consider the results from the observations of maxima and of minima as equally probable, so that by combining them we have for the elements,

Max., 1893 Jan. $9.515 \pm 0^d.011 + (0^d.882405 \pm 0^d.00002)n$
Min., 1893 Jan. $9.224 \pm 0^d.012 + (0^d.882405 \pm 0^d.00002)n$

The light-curve is exceedingly regular, the rise to maximum being uninterrupted; after maximum also the star appears to decline steadily and regularly. The period of increase indicated by the elements is 0.291 days, or very nearly seven hours. The period of decrease is twice as great.

R Trianguli Australis.

$\alpha = 15^h\ 9^m\ 3^s$, $\delta = -66° 3'.2$ (1880.0).

The observations of this star were grouped in sets of 61 days, and a mean curve drawn for each group of observations. The period used in reducing was 3.389 days. The following are the dates of maxima and minima thus obtained, with the number of observations and relative weight of each group.

P	Maxima	Minima	No. obs.	wt.
—10	1891 May 20.5	1891 May 23.1	21	2
9	July 20.5	July 23.0	37	3
5	1892 Mar. 20.5	1892 Mar. 23.2	8	1
4	May 20.5	May 23.0	28	2
3	July 20.55	July 23.0	17	2
2	Sept. 19.54	Sept. 22.1	7	1
— 1	Nov. 19.55	Nov. 22.1	14	2
0	1893 Jan. 19.60	1893 Jan. 22.18	10	1

A preliminary computation for the dates of maxima yields the approximate values,

$$E = 1893 \text{ Jan. } 19.57 \qquad P = 61^d.01$$

P being the multiple corresponding to 18 single periods;

and determining the corrections to these quantities by the residuals and weights in the following table we obtain

$$\Delta E = -0^d.006 \quad , \quad \Delta P = -0^d.0025 \quad , \quad P = 61^d.0075$$

The residuals from the approximate values are

P	Maxima, O—C	Minima, O—C	wt.
	d	d	
—10	—0.03	—0.05	2
9	— .02	+ .06	3
5	+ .02	— .10	1
4	+ .03	+ .11	2
3	— .01	+ .12	2
2	— .02	+ .03	1
— 1	+ .01	+ .04	2
0	—0.03	—0.03	1

Thus from the maxima only we obtain the elements,

$$\text{Max.} = 1893 \text{ Jan. } 19.564 + 3^d.3893\, n$$

Similarly we find from the minima,

$$\text{Min.} = 1893 \text{ Jan. } 22.092 + 3^d.38921\, n$$

The interval from maximum to minimum is $2^d.528$, and that from minimum to maximum again $0^d.861$.

κ *Pavonis.*

$\alpha = 18^h\, 44^m\, 34^s$, $\delta = -67^\circ\, 22'.8$ (1880.0).

The observations during 1891 and 1892 were combined into sets of 45 days, and mean curves constructed, the period used in reducing being $9^d.100$. The following were the dates thus obtained for the maxima during 1891 and 1892. When the observations in any period were so few as not to indicate with tolerable exactness the mean maximum, no reductions were made.

P	Maxima	wt.	O—C
			d
—13	1891 May 21.78	1	+0.02
12	July 6.30	1	.00
11	Aug. 20.85	1	— .05
9	Nov. 19.75	1	+ .05
5	1892 May 19.73	1	+ .07
4	July 4.40	1	— .10
3	Aug. 19.00	1	— .20
— 2	Oct. 3.20	½	+0.10

Assuming $E = 1893$ Jan. 2.30, and P the duration of five periods, $= 45^d.50$, we have from the data of the table,

$$\Delta E = +0^d.077 \quad . \quad \Delta P = +0^d.0072$$

which give

$$\text{Max.} = 1893 \text{ Jan. } 2.377 + 9^d.1014\, n$$

The minimum of this variable is not clearly marked, the curve having the appearance of a truncated cone placed on a level plain.

The time used in the above discussion is that of the meridian 22½° East of Greenwich. The method of observation is that of ARGELANDER.

Lovedale, Alice, South Africa.

OPPOSITION OF *MARS*, 1892,

OBSERVATIONS OF DECLINATION MADE WITH THE 4.8-INCH MERIDIAN CIRCLE OF THE WASHBURN OBSERVATORY, MADISON, WIS.,

By A. S. FLINT, ASSISTANT ASTRONOMER.

[Communicated by GEORGE C. COMSTOCK, Director.]

The following statement of results is given out pending their detailed publication in the volumes of this Observatory.

The method of observing recommended in Professor EASTMAN's circular was followed strictly; but, on account of the inadaptability of the prism first received, the reversing prism did not come into use until July 24. Otherwise the general conditions of observing were the same as with previous work with this instrument. The normal observation consisted of four bisections of the object symmetrical with reference to the middle transit-thread, the prism being reversed on the passage of the middle group of transit-threads. On the stars, the first and fourth bisections were made with one of the declination-threads, the second and third bisections with the other. The equatorial distances of bisection from middle thread were 10ˢ and 14ˢ. An effort was made to bring the declination-threads to the distance 16″, recommended in Professor EASTMAN's circular, but it was found to be impracticable. In the absence of facilities for mounting a pair of threads at a required distance with exactness, the regular threads at their normal distance 11″ were employed throughout.

The microscopes were read twice on *Mars*, but in general only once on the stars. The same eyepiece, of power 149, was used throughout. With the exception of a few nights, the two observers worked together, one on alternate nights, making the pointings at the telescope, while the other read the microscopes. All the declinations given are corrected for refraction (Pulkowa Tables), reduction to the meridian, sine and cosine flexure, division-correction: and, where required, for inclination of threads, thread of bisection, systematic difference for prism, and systematic difference between circle west and circle east. With very few exceptions the circle was set finally for each object by means of the first reading microscope and the fine motion, so that the microscope heads always read very nearly zero seconds; and, as the error of runs was examined and adjusted, if necessary, at each reversal of the instrument, this error was neglected as insensible. Also the errors of the micrometer-screw, as resulting from previous investigations, were neglected as insensible. The declinations of *Mars* were corrected, in addition, for defective illumination.

The inclination of the threads was deduced from all the extreme bisections of the stars, with the result: correction to declination $= (-0''.0204 \pm 0''.00026)\tau$, where τ is the equatorial interval in seconds of time.

The distance between the threads was deduced both from all the nadir observations and from all the complete star observations. The former gave $11''.13 \pm 0''.016$, the latter $11''.07 \pm 0''.014$.

Previous to July 24 a series of corrections to observations made without the prism have to be considered. For the stars this correction was deduced from the same data that were employed for inclination. The results were zero for observer C, and +0″.134 ±0″.058 for observer F. For *Mars* all the observations made with the prism were discussed, and the results plotted in curves for the separate observers. On the assumption that the correction was a function of the apparent diameter of *Mars*, the correction for any date previous to July 24 was taken from the curve for the date on which *Mars* had the same apparent diameter as on the date in question. The highest correction shown in the curves is about +0″.60 for both observers.

The mean results for declinations of the stars were compared for systematic difference between circle west and circle east. The result for observer C was so small that it was neglected; but, for observer F, the declinations both of the stars and of *Mars* were corrected in consequence by ±0″.38 according as the circle was west or east. The probable error of this correction is ±0″.017.

The probable error of a single observed declination of a star, as deduced from all the observations, is fairly represented by ±0″.40. The magnitudes of the stars appear to make no sensible difference, although at times the fainter stars were difficult on account of a thick sky.

The corrections to the *American Ephemeris* from the final declinations of *Mars*, as corrected by means of the comparison-stars, were plotted in a curve for both observers together. It is evident that there is no systematic difference between the observers. The curve shows, in a slight degree, two maxima and two minima: the former on July 12, —0″.20, and August 18, —1″.10; the latter, on August 5, —1″.35, and September 11, —1″.80. The ephemeris was corrected for parallax by the formula

$$p\delta = 8''.848\ \frac{\rho}{\Delta}\ \sin z'$$

where z′ is the geocentric zenith distance.

The declinations given below are all referred to the nadir and to the latitude adopted for the instrument, +43° 4′36″.72.

Apparent Declinations of *Mars* and of Comparison-Stars Observed at the Washburn Observatory. Madison, Wis., 1892

1892	Circ.	Obs.	Oe.Arg.S. 20970	*η Capric.*	*27 Capric.*	*φ Capric.*	*Mars*	Lac. 8851	*41 Capric.*	DM. —20°6923	Ll. 42700
			h m M 20 50.6, 7.0	h m M 20 58.2, 5.0	h m M 21 3.4, 6.5	h m M 21 9.5, 5.5		h m M 21 29.1, 6.0	h m M 21 35.8, 5.8	h m M 21 41.7, 7.5	h m M 21 49.6, 7.2
			—22° 25′ ″	—20° 16′ ″	—20° 59′ ″	—21° 5′ ″	° ′ ″	—23° 55′ ″	—23° 44′ ″	—20° 4′ ″	—21° 38′ ″
June 25	W	C	4.18	48.49	18.01	53.07	—20 15 4.63	56.39	55.76	30.99	53.13
27		F	4.78	49.95	18.24	53.31	19 50.54	56.75	57.35	30.76	52.28
29		C	3.77	48.53	17.28	52.58	25 30.30	56.19	56.17	30.17	51.99
30		F	4.27	48.46	17.63	53.29	28 40.22	57.27	55.55	30 26	51.63
July 4		C	3.97	48.50	17.68	52.57	43 31.01	56.49	56.00	30.43	51.39
5		F	4.34	48.85	17.55	52.94	47 45.31	56.28	55.91	29.97	51.47
6		C	4.00	48.51	17.26	52.06	20 52 12.04	56.70	55.48	29.75	51.49
11	W	F	4.79	48.86	17.37	52.21	21 17 15.22	56.57	55.50	. . .	51.54
13	E	C	3.99	48.93	17.47	52.40	28 27.56	56.55	55.96	29.25	50.72
15		F	3.79	47.58	16.64	50.97	40 14.23	55.15	54.42	27.32	50.41
16		C	4.15	48.57	17.39	52.22	46 20.43	56.90	56.48	30.26	51.14
17		F	4.17	48.47	17.46	52.90	21 52 31.31	56.89	56.26	29.44	51.13
20		F	4.49	47.68	16.94	52.34	22 11 34.90	56.29	55.81	29.25	51.13
21		C	4.02	48.54	16.84	52.46	18 3.40	55.96	54.81	28.17	49.75
22		F	3.06	48.09	. . .	. . .	24 32.61	55.58	. . .	28.37	. . .
24		C	4.36	47.15	16.07	52.01	37 32.97	55.66	54.77	28.39	51.08
25		F	4.73	48.01	16.52	. . .	44 1.56	. . .	54.77	. . .	. . .
26	E	C	3.05	47.72	16.30	51.56	—22 50 26.95	55.23	55.38	28.81	50.50

1892	Circ.	Obs.	Lac. 8463	Lac. 8506	*17 Capric.*	Lac. 8612	*Mars*	Lac. 8813	Lac. 8832	Lac. 8851	Oe.Arg.S. 21562
			h m M 20 23.2, 6.2	h m M 20 31.7, 7.0	h m M 20 39.9, 5.9	h m M 20 46.7, 7.0		h m M 21 19.6 6.0	h m M 21 24.2, 7.8	h m M 21 29.1, 6.0	h m M 21 35.4 7.8
			—22° 44′ ″	—24° 36′ ″	—21° 54′ ″	—24° 11′ ″	° ′ ″	—24° 17′ ″	—25° 39′ ″	—23° 55′ ″	—22° 24′ ″
July 29	E	C	52.83	10.24	16.01	8.12	—23 9 14.71	4.03	47.58	56.23	57.72
30		F	53.88	12.22	17.34	9.54	15 20.43	5.33	46.67	55.90	57.66
Aug. 1		C	51.49	10.47	15.82	7.72	27 0.17	4.07	47.04	55.11	57.24
3	E	F	52.98	11.58	17.48	9.42	38 1.64	5.22	. . .	55.29	57.44
4	W	C	53.16	11.89	17.00	9.84	43 14.02	5.16	47.29	55.33	57.91
5		F	53.73	12.54	17.47	9.62	48 13.51	5.17	48.32	. . .	57.58
6		C	54.01	11.68	17.58	9.06	52 59.22	4.55	48.40	56.65	58.69
7		F	54.01	. . .	17.95	. . .	23 57 30.53	. . .	. . .	. . .	. . .
10	W	C	53.44	12.91	18.28	9.49	—24 9 30.58	4.43	47.81	55.77	57.44

1892	Circ.	Obs.	Oe. Arg. S. 20429	Lac. 8463	Lac. 8506	17 *Capric.*	*Mars*	Lac. 8734	Ll 41404	ζ *Capric.*	37 *Capric.*
			h m M 20 15.1, 7.0	h m M 20 23.2, 6.2	h m M 20 31.7, 7.0	h m M 20 39.9, 5.9		h m M 21 7.0, 7.0	h m M 21 14.5, 7.5	h m M 21 20.5, 4.0	h m M 21 28.8 6.2
			—23° 49′	—22° 44′	—24° 36′	—21° 54′		—25° 17′	—22° 50′	—22° 52′	—20° 33′
			″	″	″	″	° ′ ″	″	″	″	″
Aug. 11	W	F	0.48	52.06	10.65	15.73	—24 12 57.21	13.46	29.24	35.26	46.72
12		C	1.53	53.16	10.52	17.65	16 8.19	. . .	28.87	35.11	47.42
13		C	. . .	53.68	12.04	17.56	19 0.21	13.58	29.38	. . .	47.06
14		F	. . .	53.63	12.82	18.50	21 33.74	13.23	29.09	35.03	46.86
15		C	2.59	54.45	12.30	18.28	23 49.96	14.22	29.82	36.03	46.70
16		F	2.71	54.13	12.21	18.05	25 47.22	13.87	29.91	36.42	47.24
17		C	1.92	53.89	11.18	16.93	27 24.40	13.73	29.92	35.61	47.09
18		F	1.81	53.28	11.66	16.67	28 44.26	13.02	28.84	35.51	45.80
19		C	1.99	53.72	11.73	17.13	29 44.43	12.30	28.65	35.21	45.93
21		F	1.25	53.31	12.37	17.52	30 46.39	14.27	. . .	. . .	. . .
24		C	3.03	53.85	12.43	17.85	29 54.44	14.46	29.58	36.10	47.37
25		F	2.90	54.17	12.46	17.68	28 58.97	14.03	29.57	35.94	46.98
27		C	. . .	52.85	11.95	17.30	26 10.78	13.54	29.18	34.93	46.29
29	W	F	2.55	54.46	13.12	18.29	22 10.70	15.08	30.17	36.37	47.93
31	E	C	2.79	53.12	12.17	16.83	16 58.99	14.07	29.00	35.41	47.18
Sept. 1		F	2.48	53.23	12.97	17.28	13 57.21	14.96	29.77	36.08	47.47
2		C	2.72	53.76	12.56	17.33	24 10 39.23	14.33	30.25	36.41	47.97
5		F	3.40	54.90	. . .	18.58	23 59 8.90	15.01	31.35	36.66	47.38
9		C	3.91	54.82	13.58	17.95	40 16.10	15.38	30.03	36.78	47.66
12		F	. . .	. . .	. . .	. . .	23 40.12	. . .	. . .	. . .	. . .
14		F	2.27	53.56	12.58	17.40	11 28.06	13.97	29.60	35.90	46.82
15		C	4.35	55.23	14.00	18.61	23 5 5.48	15.99	31.34	36.95	48.17
16		F	3.10	54.51	13.87	18.07	22 58 28.64	15.93	31.28	37.34	48.37
17		C	5.74	55.97	15.63	19.58	51 41.52	16.62	31.70	37.52	48.62
19		F	4.29	55.14	14.92	18.49	37 27.11	15.86	31.00	36.89	48.30
20		C	4.20	55.08	13.84	18.31	30 2.96	16.07	30.74	37.18	48.18
21		F	5.46	56.30	15.09	20.26	22 29.66	17.03	31.93	38.13	49.37
22		C	5.90	56.30	15.83	20.11	14 43.22	. . .	. . .	38.13	49.58
23	E	F	. . .	57.09	. . .	20.03	—22 6 45.11	. . .	. . .	38.77	49.88

The initial letters, denoting the observer at the telescope, are C for Prof. G. C. Comstock, and F for Mr. A. S. Flint.

Washburn Observatory, Madison, Wis., 1893 *March* 10.

ON THE ORBIT OF COMET *g* 1892,

BY PHILLIPS ISHAM AND J. G. PORTER.

Introductory Note. The following investigation was undertaken at my suggestion by Mr. Phillips Isham, a member of the senior class of the University of Cincinnati, and acting assistant at the Cincinnati Observatory, as a graduation-thesis. Besides taking a general oversight of the work, I have assisted somewhat in the computation of the ephemeris, and duplicated such portions as seemed necessary to guard against errors. All observations which have come to hand up to the present time (the end of March) have been used, with the exception of a few for which no position of the comparison-star was available. It is probable, of course, that more observations will be published in the near future; but though the introduction of additional data will naturally strengthen the determination, I do not consider it likely that they will materially alter the results, unless indeed later observations than it was found possible to obtain at this observatory were made elsewhere. It will, moreover, be a comparatively light matter to recompute the numerical terms and solve the equations again, if the observations hereafter published seem to warrant it. Since the comet during its period of visibility did not pass very near to any planet, it was not thought necessary to take perturbations into account. An attempt was made to determine the correction to the eccentricity, but, as will be seen, without success, and an inspection of the final residuals shows that no possible value of Δe would materially reduce them.

J. G. Porter.

The elements used in computing the preliminary ephemeris were obtained from observations on Nov. 25, Dec. 20 and Jan 10. They are as follows:

$$T = 1893 \text{ Jan. } 6.51945 \text{ Berlin M.T.}$$

$$\left.\begin{aligned} \Omega &= 185^\circ\ 38'\ 49''.1 \\ i &= 143\ \ 51\ \ 52.1 \\ \omega &= \ \ 85\ \ 12\ \ 59.0 \end{aligned}\right\}\ 1892.0$$

$$\log q = 0.0774040$$

The comparison of the separate observations with this ephemeris, in the sense computed *minus* observed, are given in the table below.

	No.	Place of Observation	Berlin M.T.	Observed α	Par.	Observed δ	Par.	$\cos\delta\,\Delta\alpha$	$\Delta\delta$
				h m s	s	° ′ ″	″	″	″
Group I	1	Cambridge, Mass.	Nov. 21.92265	12 59 15.62	—0.23	+13 50 27.3	+2.9	+13.5	— 1.3
	2	Wien	24.64201	13 3 4.39	—0.24	+15 4 36.5	+3.6	+10.0	— 0.6
	3	Kopenhagen	24.72132	13 3 10.39	—0.16	+15 6 52.0	+3.8	+22.2	+ 1.4
	4	Wien	25.62919	13 4 31.13	—0.25	+15 32 50.8	+3.8	+18.8	[+51.5]
	5	Kiel	25.65083	13 4 33.32	—0.22	+15 34 18.7	+4.1	+14.5	+ 1.9
	6	Königsberg	25.65965	13 4 33.46	—0.20	+15 34 36.9	+4.0	+23.6	— 0.5
	7	Kopenhagen	25.67358	13 4 35.69	—0.20	+15 35 1.0	+4.1	+ 9.5	+ 0.7
	8	Kremsmünster	25.71937	13 4 40.11	—0.19	+15 36 26.1	+3.3	+ 5.0	— 0.4
	9	Königsberg	26.67157	13 6 6.10	—0.20	+16 5 49.9	+4.0	+17.6	— 2.0
	10	Padua	29.69534	13 11 0.70	—0.25	+17 47 42.7	+3.3	+ 8.6	+ 3.3
	11	Cincinnati	29.99690	13 11 30.31	—0.23	+17 58 39.0	+2.6	[+28.0]	+ 4.7
	12	Strassburg	30.61530	13 12 39.71	—0.28	+18 22 46.9	+4.1	+ 6.1	— 0.9
	13	Kopenhagen	30.72643	13 12 47.54	—0.17	+18 25 49.8	+4.0	+15.5	0.0
	14	Padua	30.74022	13 12 49.88	—0.20	+18 26 1.6	+3.1	+ 3.4	[+20.4]
	15	Cincinnati	30.99360	13 13 16.35	—0.24	+18 35 59.4	+2.6	+12.0	+ 1.6
	16	Padua	Dec. 1.74119	13 14 37.96	—0.19	+19 4 58.8	+3.1	+ 6.8	+ 9.2
Group II	17	Greenwich	Dec. 12.64925	13 40 45.62	—0.38	+28 37 1.1	+5.1	+11.6	4.0
	18	Greenwich	15.63292	13 51 16.53	—0.43	+32 17 36.5	+5.6	+28.9	— 7.0
	19	Greenwich	15.78241	13 51 52.75	—0.23	+32 29 18.1	+3.3	+ 8.2	+12.1
	20	Cincinnati	17.91784	14 1 5.16	—0.55	+35 30 51.2	+3.2	+17.5	+ 3.8
	21	Poughkeepsie	17.95993	14 1 16.61	—0.38	+35 34 33.3	+2.0	+20.8	+ 9.1
	22	Kremsmünster	18.73970	14 5 4 97	—0.30	+36 45 59.4	+2.5	+11.5	+ 5.9
	23	Kremsmünster	19.70600	14 10 9.96	—0.36	+38 18 5.2	+2.9	+ 5.9	+16.3
	24	Hamburg	20.52226	14 14 48.44	—0.46	+39 39 17.8	+7.9	+11.6	+15.0
	25	Kremsmünster	20.62613	14 15 25.56	—0.55	+39 50 1.2	+4.6	+11.6	+ 8.6
	26	Cincinnati	20.80860	14 16 32.22	— 0.64	+40 8 34.9	+6.4	+ 4.8	+13.2
	27	Poughkeepsie	20.95201	14 17 24.16	—0.49	+40 23 25.5	+1.8	+11.5	+13.9
	28	Hamburg	22.51793	14 27 49.92	—0.50	+43 10 34.8	+8.3	+19.7	+17.8
	29	Hamburg	22.58590	14 28 19.85	—0.57	+43 18 18.9	+6.6	+16.0	+ 5.8
Group III	30	Greenwich	Dec. 23.54494	14 35 39.46	—0.54	+45 5 57.8	+8.4	+22.5	+18.0
	31	Hamburg	24.50087	14 43 47.33	—0.50	+46 57 4.2	+9.0	+17.4	+11.3
	32	Hamburg	24.50935	14 43 51.97	—0.52	+46 58 2.9	+8.8	+17.1	+12.8
	33	Dresden	24.68440	14 45 27.50	—0.59	+47 18 54.1	+3.2	+14.3	+ 7.5
	34	Hamburg	25.48428	14 53 8.17	—0.48	+48 54 8.6	+9.6	+14.1	+22.4
	35	Lyons	28.77517	15 34 4.12	—0.68	+55 37 0.5	—0.2	+17.1	+11.2
	36	Cincinnati	28.90324	15 36 3.79	—1.11	+55 52 30.4	+3.8	+ 8.9	+ 7.2
	37	Lyons	29.73383	15 49 40.06	—0.93	+57 31 35.7	+1.2	+16.6	+ 9.3
	38	Lyons	29.76318	15 50 10.63	—0.82	+57 35 4.3	+0.1	+15.5	+ 8.4
Group IV	39	Northfield	Jan. 7.68869	19 50 10.11	+1.03	+65 25 41.6	+9.1	+19.1	— 8.2
	40	Cincinnati	9.95030	20 49 36.76	—0.95	+63 14 55.3	+9.5	+23.7	— 4.6
	41	Poughkeepsie	10.56619	21 3 21.81	+1.27	+62 27 57.3	+4.0	[+31.4]	—14.6
	42	Cincinnati	10.59456	21 4 0.35	+1.32	+62 25 33.2	+3.8	+18.3	— 6.2
	43	Poughkeepsie	11.54626	21 23 15.25	+1.18	+61 6 0.2	+0.7	[+35.1]	— 7.1
	44	Poughkeepsie	11.57650	21 23 51.78	+1.19	+61 3 34.6	+4.5	+20.3	—23.2
	45	Poughkeepsie	13.53619	21 56 37.36	+0.97	+58 4 33.8	+1.7	[+31.5]	—13.7
	46	Cincinnati	13.57385	21 57 11.01	+1.05	+58 0 56.0	+1.8	+26.1	— 8.4
Group V	47	Cincinnati	Jan. 15.64310	22 23 42.74	+0.95	+54 45 30.7	+3.3	+ 8.0	—11.8
	48	Poughkeepsie	16.55106	22 33 19.19	+0.82	+53 20 54.7	+2.1	+16.3	—12.0
	49	Northfield	16.57246	22 33 31.29	+0.71	+53 18 55.7	+1.3	+24.1	—10.7
	50	Poughkeepsie	16.64350	22 35 41.01	+0 84	+53 15 48.7	+5.6	[-760.6]	[-221.4]
	51	Poughkeepsie	17.55432	22 42 46.16	+0.77	+51 49 17.8	+1.0	[+33.6]	— 7.9
	52	Cincinnati	17.59250	22 43 9.29	+0.81	+51 45 55.0	+2.2	+10.2	—12.5
	53	Poughkeepsie	17.64854	22 43 39.11	+0.78	+51 40 50.2	+5.7	+ 6.8	—13.5
	54	Cincinnati	19.54425	22 58 42.92	+0.62	+48 55 48.5	+0.7	+16.1	—11.8
	55	Poughkeepsie	19.57116	22 58 51.08	+0.70	+48 53 25.8	+2.8	[+49.1]	— 7.0
	56	Poughkeepsie	19.65915	22 59 32.62	+0.69	+48 46 12.9	+5.7	+ 9.8	—20.1
	57	Poughkeepsie	20.56696	23 5 37.19	+0.52	+47 31 21.8	+2.6	[+48.6]	—10.2
	58	Poughkeepsie	21.57102	23 11 50.08	+0.63	+46 11 39.2	+2.8	+23.0	+ 4.2
	59	Cincinnati	23.54978	23 22 26.94	+0.51	+43 45 21.4	+1.3	+13.0	—19.4

	No.	Place of Observation	Berlin M.T.	Observed α	Par.	Observed δ	Par.	$\cos\delta\,\Delta\alpha$	$\Delta\delta$
				h m s	s	° ′ ″	″	″	″
Group VI	60	Cincinnati	Feb. 3.54664	23 59 25.01	+0.34	+33 38 34.5	+1.9	+ 7.7	— 6.2
	61	Cincinnati	7.59061	0 8 2.51	+0.35	+31 3 16.0	+2.6	+12.3	— 7.5
	62	Cincinnati	11.55292	0 15 9.97	+0.29	+28 55 39.3	+2.1	+13.2	— 6.9
	63	Cincinnati	13.55619	0 18 23.77	+0.29	+27 58 46.6	+2.2	+ 9.2	— 5.8
	64	Northfield	14.60348	0 19 59.82	+0.27	+27 30 53.0	+2.8	+10.2	— 7.5

The first Greenwich observation of Dec. 15, as published in the *R.A.S. Monthly Notices* of January 1893, is incorrectly reduced in declination. The error was corrected and the position of the comparison-star taken from the Leiden A.G. Zones, instead of from LALANDE. The places of several of the comparison-stars employed evidently need redetermining, and a few observations have been rejected either for this or other reasons. Such cases are indicated by brackets. Dr. WILSON kindly communicated by letter the Northfield observation of Feb. 14.

The mean of the residuals for each group was adopted as the correction to the ephemeris for the middle time, and the differential coefficients for these times were computed, thus furnishing the following equations of condition, in which the unit for ΔT is the third decimal place, that for Δq the fifth place, and that for Δe the fourth place. The last column shows the residuals which result by substituting the values of the unknown quantities as derived from the solution of the normal equations.

EQUATIONS OF CONDITION.

From Right-Ascensions.

								Resid.
1	$0 = +11.7$	$-0.187\,\Delta\pi$	$+0.646\,\Delta\Omega$	$-0.526\,\Delta i$	$+0.091\,\Delta T$	$-0.790\,\Delta q$	$-0.512\,\Delta e$	+0.3
2	$0 = +13.8$	$+0.310$	-0.322	-0.941	-1.629	-1.060	-0.942	0.0
3	$0 = +15.9$	$+0.807$	-1.291	-0.968	-3.385	-1.098	-1.016	—2.0
4	$0 = +21.5$	$+1.469$	-2.674	$+0.697$	-5.658	$+0.337$	$+0.281$	—2.8
5	$0 = +14.2$	$+0.302$	-0.440	$+1.033$	-1.440	$+0.887$	$+0.607$	+1.0
6	$0 = +10.5$	-0.183	$+0.544$	$+0.644$	$+0.197$	$+0.766$	$+0.237$	0.0

From Declinations.

7	$0 = +\ 1.1$	$+0.707\,\Delta\pi$	$-1.122\,\Delta\Omega$	$-0.267\,\Delta i$	$-1.766\,\Delta T$	$+1.467\,\Delta q$	$-1.010\,\Delta e$	+2.0
8	$0 = +\ 8.5$	$+1.154$	-2.039	-0.184	-3.786	$+2.032$	-1.417	+1.0
9	$0 = +12.0$	$+1.276$	-2.340	$+0.197$	-4.448	$+2.182$	-1.111	+0.8
10	$0 = -10.3$	-0.613	$+1.088$	$+0.764$	$+2.261$	$+2.346$	-0.107	—1.9
11	$0 = -11.3$	-1.004	$+1.796$	-0.189	$+3.366$	$+1.907$	-1.018	+0.3
12	$0 = -\ 6.8$	-0.672	$+1.108$	-0.323	$+1.770$	$+1.119$	-0.947	—2.8

Normal Equations.

$0 = +\ 96.93$	$+\ 8.526\,\Delta\pi$	$-14.764\,\Delta\Omega$	$+0.031\,\Delta i$	$-\ 29.286\,\Delta T$	$+\ 1.419\,\Delta q$	$-2.541\,\Delta e$
$0 = -160.96$	-14.764	$+26.338$	-0.405	$+\ 51.391$	$-\ 2.967$	$+4.077$
$0 = -\ \ 1.22$	$+\ 0.031$	$-\ 0.405$	$+4.935$	$+\ \ 0.277$	$+\ 4.738$	$+3.849$
$0 = -375.95$	-29.286	$+51.391$	$+0.277$	$+105.079$	$-\ 3.419$	$+9.366$
$0 = -\ 23.73$	$+\ 1.419$	$-\ 2.967$	$+4.738$	$-\ \ 3.419$	$+26.622$	-7.035
$0 = -\ 25.65$	$-\ 2.541$	$+\ 4.077$	$+3.849$	$+\ \ 9.366$	$-\ 7.035$	$+8.978$

The solution shows that Δe is indeterminate. It was therefore assumed zero. The solution was also repeated in the inverse order, beginning with Δq, in order to obtain the weights of the different quantities. The sum of the squares of the residuals given by the equations of condition being 30.0, we find the probable error of the unit of weight by the formula

$$r = 0.6745\sqrt{\frac{30}{12-5}} = 1.40$$

The probable errors of the quantities resulting from the solution of the normal equations are then found by dividing r by the square root of their respective weights. We thus obtain:

$$\begin{array}{llll}
\Delta\pi = -\ 1''.7 & \pm 3''.0 & \Delta T = +0.01363 & \pm 0.00072 \\
\Delta\Omega = -21.4 & \pm 1.7 & \Delta q = +0.0000096 & \pm 0.0000030 \\
\Delta i = -\ 3.2 & \pm 0.7 & \Delta e = \ \ 0 & \\
\Delta\omega = +19.7 & \pm 3.5 & &
\end{array}$$

Hence the final values of the elements:

$$T = 1893 \text{ Jan. } 6.53308 \pm 72 \text{ Berlin M.T.}$$

$$\left.\begin{array}{ll}
\Omega = 185^\circ\ 38'\ 27''.7 & \pm 1''.7 \\
i = 143\ \ 51\ \ 48.9 & \pm 0.7 \\
\omega = \ \ 85\ \ 13\ \ 18.7 & \pm 3.5
\end{array}\right\}\ 1892.0$$

$$\log q = 0.0774075 \quad \pm 11$$

With these elements the formulas for the heliocentric coordinates become:

$$\left.\begin{aligned} x &= [9.9992693]r\sin(350^\circ\ 39'\ 39''.5+v)\\ y &= [9.7081030]r\sin(\ 75\ \ \ 3\ \ \ 1.0+v)\\ z &= [9.9353835]r\sin(\ 82\ 37\ 11.7+v)\end{aligned}\right\}1892.0$$

$$\left.\begin{aligned} x &= [9.9992656]r\sin(350\ 38\ 58.5+v)\\ y &= [9.7081212]r\sin(\ 75\ \ \ 1\ 31.3+v)\\ z &= [9.9353820]r\sin(\ 82\ 36\ 48.3+v)\end{aligned}\right\}1893.0$$

As a final check the normal places were recomputed with the new system of elements; the residuals coming out substantially the same as by direct substitution in the equations of condition.

In order to exhibit the residuals of the separate observations, the ephemeris was recomputed for intervals of a few days, and the corresponding corrections to the former ephemeris plotted. A curve drawn through these points then furnished with tolerable accuracy the correction for any other date. In this way the following table was formed, in which the numbers correspond to those in the first table.

No.	Place	Date	$\cos\delta\,\Delta\alpha$	$\Delta\delta$
			″	″
1	Cambridge, Mass.	Nov. 21	+ 2.5	+ 0.7
2	Wien	24	— 1.3	+ 1.1
3	Kopenhagen	24	+10.9	+ 3.1
4	Wien	25	+ 7.5	+52.8
5	Kiel	25	+ 3.2	+ 3.2
6	Königsberg	25	+12.3	+ 1.0
7	Kopenhagen	25	— 1.8	+ 2.0
8	Kremsmünster	25	— 6.3	+ 0.9
9	Königsberg	26	+ 6.2	— 1.1
10	Padua	29	— 3.0	+ 3.3
11	Cincinnati	29	+16.4	+ 4.7
12	Strassburg	30	— 5.6	— 1.1
13	Kopenhagen	30	+ 3.8	— 0.2
14	Padua	30	— 8.3	+20.2
15	Cincinnati	30	+ 0.3	+ 1.4
16	Padua	Dec. 1	— 5.0	+ 8.8
17	Greenwich	12	— 1.1	— 8.7
18	Greenwich	15	+15.8	—13.0
19	Greenwich	15	— 4.9	+ 6.1
20	Cincinnati	17	+ 4.0	— 3.2
21	Poughkeepsie	17	+ 7.3	+ 2.1
22	Kremsmünster	18	— 2.2	— 1.4
23	Kremsmünster	19	— 7.9	+ 8.8
24	Hamburg	20	— 2.4	+ 7.2
25	Kremsmünster	20	— 2.4	+ 0.8
26	Cincinnati	20	— 9.2	+ 5.4
27	Poughkeepsie	20	— 2.5	+ 6.1
28	Hamburg	22	+ 4.5	+ 9.1
29	Hamburg	22	+ 0.8	— 2.9
30	Greenwich	23	+ 6.8	+ 8.4
31	Hamburg	24	+ 1.2	+ 1.4
32	Hamburg	24	+ 0.9	+ 2.8
33	Dresden	Dec. 24	— 1.9	— 2.5
34	Hamburg	25	— 3.1	+11.9
35	Lyons	28	— 2.8	— 0.5
56	Cincinnati	28	—11.0	— 4.5
37	Lyons	29	— 4.2	— 2.4
38	Lyons	29	— 5.3	— 3.3
39	Northfield	Jan. 7	— 6.4	— 0.2
40	Cincinnati	9	+ 1.7	+ 5.6
41	Poughkeepsie	10	+10.1	— 4.8
42	Cincinnati	10	— 3.0	+ 4.6
43	Poughkeepsie	11	+15.0	+ 4.7
44	Poughkeepsie	11	+ 0.2	—11.4
45	Poughkeepsie	13	+13.5	+ 0.1
46	Cincinnati	13	+ 8.1	+ 5.4
47	Cincinnati	15	— 8.2	+ 2.4
48	Poughkeepsie	16	+ 0.4	+ 2.1
49	Northfield	16	+ 8.2	+ 3.4
50	Poughkeepsie	16	-	-
51	Poughkeepsie	17	+18.4	+ 6.0
52	Cincinnati	17	— 5.0	+ 1.4
53	Poughkeepsie	17	— 8.4	+ 0.4
54	Cincinnati	19	+ 2.2	+ 1.0
55	Poughkeepsie	19	+35.2	+ 5.8
56	Poughkeepsie	19	— 4.1	— 7.3
57	Poughkeepsie	20	+35.4	+ 1.8
58	Poughkeepsie	21	+10.2	+15.2
59	Cincinnati	23	+ 1.0	— 9.6
60	Cincinnati	Feb. 3	— 2.9	— 1.4
61	Cincinnati	7	+ 1.8	— 3.4
62	Cincinnati	11	+ 2.7	— 2.9
63	Cincinnati	13	— 1.3	— 1.9
64	Northfield	14	— 0.2	— 3.6

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NEW ASTRONOMICAL WORK.

Catalogue of the Magnitudes of Southern Stars from 0° to —30° Declination, to the Magnitude 7.0 inclusive. By EDWIN F. SAWYER. Cambridge, 1893.

This work consists of a determination, made between the years 1882 and 1887, of the magnitudes of 3415 stars from the equator to 30° south. The average number of observations to each star is four. The system of magnitudes adopted is that of the *Uranometria Argentina*, and the mode of observation is that of sequences, by ARGELANDER's method. The fact that eight new variables were discovered during the progress of the work, — most of which have short periods and small range, and all of which have been confirmed, — is the best testimony to its inherent accuracy. The form of publication permits the identification of the brightness of each star on the individual dates of observation, and the probable error of a single determination of magnitude is ±0ᴹ.059. It appears to be the most important and accurate photometrical work which has appeared within a decade.

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ON THE CONSTANT OF ABERRATION,

By S. C. CHANDLER.

III.

§6. STRUVE'S PRIME-VERTICAL OBSERVATIONS, 1840–55.

We now come to a series which in intrinsic importance, as well as historical interest, holds a unique position in modern astronomy. In either of these aspects it merits an especially searching investigation from the new point of view, with respect to the variation of latitude, from which we must now regard it. Such a rediscussion, of the observations of 1840–42 alone, was made under the auspices of Prof. NEWCOMB, by Messrs. ROSZEL and ANNIS (*A.J.* XII, pp. 10–12), soon after the discovery of the 427-day period in the latitude, under the assumption that this term was the full expression of this variation. A repetition of the investigation seems to be desirable for several reasons. Thus it now appears that the real form of the latitude-variation is materially different, and in order to determine properly all the constants involved, it is necessary to include in the discussion the full series of W. STRUVE's observations, running up to 1855. It is also important to conduct it in such a way that the dependence of the final results for the aberration upon the unknown constants for the latitude-variation shall be made manifest. It requires but a casual examination of the normal equations given in the paper just quoted, to show that, for some of the stars at least, these equations are not entirely independent, a multiplication by a factor reducing their effective number. Still again, by introducing an assumption of possible lateral refraction due to unequal heating of the shutter by the sun, a rejection of certain observations was made, without that rigorous examination of the effect of such rejection upon the constants deduced, which, it seems to me, is required when any arbitrary mode of treatment is adopted.

The method pursued in the following investigation has been adopted after a careful consideration of the circumstances, as the one most suitable to elucidate the delicate questions involved. It is impossible to specify all of them here. Referring to §1 for a general presentation of the conditions required for a determinate solution, and to the distribution of STRUVE's observations in time, and of his stars in right-ascension, it will be seen that the problem of finding all the unknowns, independently, by this series is somewhat indeterminate. The main difficulty is the separation of the two terms of the latitude-variation. This difficulty would have disappeared if the seven stars observed by STRUVE for the aberration, from 1840–42 had been followed through the whole interval for which he continued only three of them for the nutation, or possibly even if the three stars had been observed in nearly all months of the later years, instead of being confined to limited portions of them.

In the actual condition of things, I have thought it desirable, not only to make a direct solution for all the unknowns, but also an indeterminate one. For the latter I have therefore carried on the computations by expressing the other unknowns in terms of y and z, the constants pertaining to the 427-day term. Then, substituting values of these obtained by extraneous considerations as to their probable values, as shown by other investigations, we can ascertain the limits within which the aberration must be contained, by STRUVE's observations, and its most probable value.

So much for the general conduct of the discussion. As the numerical basis of the discussion, I took from pp. 11–17, 31–32, of NYRÉN's *Memoir on the Nutation*, for W. STRUVE's observations alone (1840–55) the values of n (using the opposite sign to conform to our notation), after verifying them and correcting one or two obvious misprints. The doubtful observations, marked with an asterisk in STRUVE's *Memoir on the Aberration* were excluded. Combining the data in groups of a few days each, rarely over ten days, we have the mean values of n, with their weights, in Table V.

Forming equations according to (35), computing the coefficients of (25) with $\theta = 0^\circ.835$, $T'_0 = 2\,394\,161$, we get the following ten sets of normal equations, which are to serve as the basis of the subsequent discussion.

υ Ursae Majoris, 1840–42.

$$\begin{array}{rrrrrl}
+71.00X & +18.55Y & +14.60Z & -14.81y & -\ 4.50z & =-\ 6''.78\\
+18.55 & +36.27 & +23.05 & -34.28 & -10.98 & =-\ 2.19\\
+14.60 & +23.05 & +34.76 & -24.88 & -20.22 & =-\ 1.39\\
-14.81 & -34.28 & -24.88 & +42.17 & +\ 7.67 & =+\ 1.41\\
-\ 1.50 & -10.98 & -20.22 & +\ 7.67 & +28.83 & =+\ 0.82
\end{array}$$

υ Ursae Majoris, 1843–55.

$$\begin{array}{rrrrrl}
+61.00X & +52.24Y & +30.14Z & -\ 7.87y & +\ 3.94z & =-\ 7''.57\\
+52.24 & +45.12 & +25.02 & -\ 7.77 & +\ 4.59 & =-\ 6.65\\
+30.14 & +25.02 & +15.94 & -\ 2.33 & +\ 0.71 & =-\ 3.52\\
-\ 7.87 & -\ 7.77 & -\ 2.33 & +20.24 & +\ 2.83 & =+\ 1.45\\
+\ 3.94 & +\ 4.59 & +\ 0.71 & +\ 2.83 & +40.78 & =-\ 3.09
\end{array}$$

ι Draconis., 1840–42.

$$\begin{array}{rrrrrl}
+60.00X & +23.02Y & -12.54Z & -\ 6.31y & +11.07z & =+12''.57\\
+23.02 & +30.65 & -\ 8.84 & -16.58 & +13.34 & =+\ 5.38\\
-12.54 & -\ 8.84 & +29.35 & -\ 1.18 & -25.42 & =-\ 1.98\\
-\ 6.31 & -16.58 & -\ 1.18 & +25.60 & +\ 3.52 & =-\ 2.82\\
+11.07 & +13.34 & -25.42 & +\ 3.52 & +34.35 & =+\ 2.54
\end{array}$$

ι Draconis, 1843–55.

$$\begin{array}{rrrrrl}
+81.00X & +50.61Y & -60.68Z & +\ 6.11y & +\ 1.27z & =+18''.56\\
+50.61 & +34.34 & -36.03 & +\ 7.06 & +\ 0.72 & =+11.89\\
-60.68 & -36.03 & +46.69 & -\ 1.84 & -\ 0.41 & =-13.84\\
+\ 6.11 & +\ 7.06 & -\ 1.84 & +39.88 & +\ 4.03 & =+\ 2.98\\
+\ 1.27 & +\ 0.72 & -\ 0.41 & +\ 4.03 & +41.01 & =-\ 3.30
\end{array}$$

o^2 *Draconis*, 1840–42.

$$\begin{array}{rrrrrl}
+42.00X & -\ 0.15Y & -\ 4.46Z & +\ 6.00y & +\ 1.53z & =+\ 2''.58\\
-\ 0.15 & +14.95 & +\ 5.52 & -12.48 & -\ 4.24 & =+\ 0.27\\
-\ 4.46 & +\ 5.52 & +27.09 & -\ 5.26 & -22.17 & =-\ 1.23\\
+\ 6.00 & -12.48 & -\ 5.26 & +20.76 & +\ 0.39 & =-\ 0.88\\
+\ 1.53 & -\ 4.24 & -22.17 & +\ 0.39 & +21.24 & =+\ 1.74
\end{array}$$

o^2 *Draconis*, 1843–55.

$$\begin{array}{rrrrrl}
+25.00X & -16.88Y & -17.10Z & -\ 5.66y & -\ 0.06z & =-\ 0''.30\\
-16.88 & +12.19 & +10.58 & +\ 3.25 & +\ 0.59 & =+\ 0.24\\
-17.10 & +10.58 & +12.81 & +\ 4.19 & +\ 0.13 & =+\ 0.27\\
-\ 5.66 & +\ 3.25 & +\ 4.19 & +11.81 & -\ 0.74 & =+\ 0.94\\
-\ 0.06 & +\ 0.59 & +\ 0.13 & -\ 0.74 & +13.19 & =-\ 0.59
\end{array}$$

β Cassiopeae, 1840–42.

$$\begin{array}{rrrrrl}
+37.00X & +\ 0.22Y & +\ 3.42Z & -\ 0.83y & -\ 2.00z & =-\ 0''.15\\
+\ 0.22 & +22.74 & +\ 4.75 & -17.29 & -\ 9.68 & =+\ 0.10\\
+\ 3.42 & +\ 4.75 & +14.30 & +\ 3.10 & -13.90 & =-\ 2.79\\
-\ 0.83 & -17.29 & +\ 3.10 & +19.20 & -\ 0.15 & =-\ 1.31\\
-\ 2.00 & -\ 9.68 & -13.90 & -\ 0.15 & +17.80 & =+\ 2.12
\end{array}$$

δ Cassiopeae, 1840–42.

$$\begin{array}{rrrrrl}
+37.00X & -\ 1.11Y & +\ 1.70Z & -\ 3.59y & +\ 1.06z & =+\ 0''.14\\
-\ 1.11 & +24.34 & +\ 2.27 & -18.27 & -\ 7.07 & =+\ 0.49\\
+\ 1.70 & +\ 2.27 & +12.66 & +\ 4.87 & -12.02 & =-\ 3.72\\
-\ 3.59 & -18.27 & +\ 4.87 & +20.58 & -\ 2.07 & =-\ 2.18\\
+\ 1.06 & -\ 7.07 & -12.02 & -\ 2.07 & +16.41 & =+\ 3.02
\end{array}$$

b Draconis, 1840–42.

$$\begin{array}{rrrrrl}
+24.00X & +\ 6.62Y & -12.32Z & +\ 7.76y & +10.11z & =+\ 0''.06\\
+\ 6.62 & +\ 4.93 & -\ 1.96 & +\ 0.04 & +\ 3.91 & =+\ 0.39\\
-12.32 & -\ 1.96 & +19.07 & -10.09 & -15.41 & =+\ 0.76\\
+\ 7.76 & +\ 0.04 & -10.09 & +\ 9.21 & +\ 6.01 & =-\ 1.13\\
+10.11 & +\ 3.91 & -15.41 & +\ 6.01 & +14.79 & =-\ 0.23
\end{array}$$

2 Hev. *Cephei*, 1840–42.

$$\begin{array}{rrrrrl}
+14.00X & -\ 1.58Y & -\ 1.40Z & +\ 0.96y & -\ 0.40z & =\ \ \ 0''.00\\
-\ 1.58 & +\ 4.21 & +\ 5.86 & -\ 2.78 & -\ 4.76 & =-\ 0.28\\
-\ 1.40 & +\ 5.86 & +\ 9.79 & -\ 2.54 & -\ 8.39 & =-\ 0.57\\
+\ 0.96 & -\ 2.78 & -\ 2.54 & +\ 5.45 & +\ 0.62 & =-\ 0.09\\
-\ 0.40 & -\ 4.76 & -\ 8.39 & +\ 0.62 & +\ 8.55 & =+\ 0.76
\end{array}$$

For the direct solution we first eliminate X, Y and Z, add the resulting elimination-equations, and solve for y and z. The values of the direct solution for Y and Z introduced in (37), and solved, give η, ζ and u. We thus obtain from the observations of the seven stars from 1840–42 alone,

$$y=-0''.055,\ z=+0''.032,\ \eta=+0''.002,\ \zeta=+0''.060,\ u=+0''.088$$

consequently the aberration, 20″.533, as against STRUVE's value, 20″.445, from the same material; a very surprising increase. From the whole data from 1840–55, however, which is necessarily much more determinate, we get

$$y=+0''.007,\ z=-0''.035,\ \eta=+0''.054,\ \zeta=-0''.085,\ u=+0''.069$$

Hence the expression of the latitude-variation, by (30) and (25), becomes,

$$\begin{aligned}\varphi-\varphi_0=-0''.035\cos(t-1842\ \text{Nov.}\ 8)\times 0°835&\\ -0''.100\cos(\odot-327°.7)&\end{aligned}\tag{43}$$

The aberration is

20″.514

which would be the definitive value from STRUVE's Prime-vertical observations, if we accept the direct solution as the best. But the indeterminate solution throws doubt upon this point. Finding the values of Y and Z in terms of y and z, we have

	Y			w_1	Z			w_2
υ Ursae Majoris 1840–1842	$-0''.021$	$+0.869\,y$	$-0.095\,z$	19.77	$+0''.013$	$+0.161\,y$	$+0.665\,z$	19.98
ι Draconis “	$+\ .031$	$+\ .685$	$-\ .265$	21.21	$+\ .029$	$+\ .197$	$+\ .825$	25.98
o^2 *Draconis* “	$+\ .034$	$+\ .833$	$-\ .023$	13.81	$-\ .043$	$+\ .002$	$+\ .832$	24.59
β Cassiopeae “	$+\ .049$	$+\ .869$	$+\ .238$	21.14	$-\ .215$	$-\ .521$	$+\ .899$	13.00
δ Cassiopeae “	$+\ .049$	$+\ .809$	$+\ .202$	23.88	$-\ .305$	$-\ .549$	$+\ .922$	12.36
b Draconis “	$+\ .096$	$+0.480$	$-\ .773$	2.94	$+\ .051$	$+\ .425$	$+0.889$	12.08
2 Hev. *Cephei* “	$+\ .086$	$+1.853$	$-\ .266$	0.66	$-\ .110$	$-\ .842$	$+1.031$	1.59
υ Ursae Majoris 1840–1855	$-\ .041$	$+0.614$	$-\ .258$	27.12	$+\ .026$	$+\ .133$	$+0.719$	22.19
ι Draconis “	$+\ .042$	$+\ .392$	$-\ .166$	25.38	$+\ .016$	$+\ .151$	$+\ .482$	36.36
o^2 *Draconis* “	$+0.060$	$+0.456$	-0.189	19.39	-0.026	-0.117	$+0.715$	28.02

where the last three values were of course derived from the addition of the two sets of normal equations for these stars.

Introducing these values of Y and Z into the second member of (37), we have the equations of condition.

υ Ursae Majoris, 1840–1842,		$-0.707\,\eta$	$-0.255\,\zeta$	$+0.565\,u$	$=$	$+0''.012$	$-0.655\,y$	$-0.103\,z$	$w_0 = 35.0$
ι Draconis,	"	$-\ .550$	$+\ .811$	$+\ .960$	$=$	$+\ .007$	$-\ .217$	$+\ .815$	25.3
o^2 *Draconis*,	"	$+\ .181$	$+\ .974$	$+\ .982$	$=$	$-\ .036$	$+\ .153$	$+\ .806$	24.1
β Cassiopeae,	"	$+\ .851$	$+\ .207$	$+\ .767$	$=$	$-\ .003$	$+\ .632$	$+\ .389$	26.6
δ Cassiopeae,	"	$+\ .815$	$-\ .053$	$+\ .667$	$=$	$+\ .056$	$+\ .688$	$+\ .116$	35.7
b Draconis,	"	$+\ .080$	$+\ .987$	$+\ .980$	$=$	$+\ .058$	$+\ .457$	$+\ .815$	12.1
2 Hev. *Cephei*,	"	$+\ .403$	$+\ .897$	$+\ .967$	$=$	$-\ .064$	$-\ .008$	$+\ .818$	1.3
υ Ursae Majoris, 1840–1855,		$-\ .707$	$-\ .255$	$+\ .565$	$=$	$+\ .022$	$-\ .468$	$-\ .001$	46.8
ι Draconis,	"	$-\ .550$	$+\ .811$	$+\ .960$	$=$	$-\ .010$	$-\ .094$	$+\ .482$	33.3
o^2 *Draconis*,	"	$+0.181$	$+0.974$	$+0.982$	$=$	-0.014	-0.031	$+0.662$	28.1

Solving the first seven, corresponding to the data used by Struve in determining the aberration, we have the normal equations.

$$\begin{array}{rrrcrrr} +69.190\,\eta & +\ 3.882\,\zeta & +\ 15.262\,u & = & +1''.036 & +54.747\,y & +\ 8.196\,z \\ +\ 3.882 & +56.160 & +\ 53.802 & = & -0.325 & +12.676 & +49.410 \\ +15.262 & +53.802 & +102.373 & = & +1.445 & +20.146 & +58.427 \end{array}$$

the solution of which gives,

$$\eta = +0''.010\ +0''.785\,y\ +0.034\,z. \quad \zeta = -0''.037\ +0.191\,y\ +0.676\,z, \quad u = +0''.032\ -0.021\,y\ +0.210\,z$$

Solving the last seven, which embrace the whole of W. Struve's observations we have the normal equations,

$$\begin{array}{rrrcrrr} +77.628\,\eta & +\ 3.090\,\zeta & +\ 6.989\,u & = & +0''.955 & +51.837\,y & +\ 8.008\,z \\ +\ 3.090 & +65.702 & +\ 61.837 & = & -0.458 & +\ 9.843 & +43.767 \\ +\ 6.989 & +61.873 & +117.079 & = & +1.713 & +18.503 & +55.007 \end{array}$$

the solution of which gives,

$$(a) \quad \eta = +0''.011\ +0.657\,y\ +0.065\,z. \quad \zeta = -0''.041\ +0.011\,y\ +0.446\,z, \quad u = +0''.036\ +0.111\,y\ +0.230\,z$$

The definitive value of the aberration, from the indeterminate solution is then,

$$(b) \qquad \mathbf{20''.481\ +0.111\,y\ +0.230\,z}$$

The question now arises what values we are to attribute to y and z. The complete answer can only be given when we know the most probable values of those constants, and for this we must wait until all the various series which can throw light on it have been discussed. It may not be premature, however, to introduce the constants of the 427-day term given by the nearly simultaneous series of Peters, on *Polaris*, with the vertical circle, which were entirely independent of the aberration. We obtained on p. 179, vol. XII, $r_1 = 0''.077$, $T'_1 = 2\,394\,108$. In the present discussion we assumed $T'_0 = 2\,394\,161$; hence by the third equation of (26), $y = +0''.054$, $z = -0.055$. Substituting these above we find $\eta = +0''.042$, $\zeta = -0''.065$, which gives the annual term in the latitude-variation,

$$-0''.077\cos(\odot - 327^\circ.1)$$

which accords very well with that term in (43). The aberration becomes, under this assumption 20″.474, which is notably less than the result of the direct solution (20″.514). It should be noted that the direct value, 20″.514, is really not logically derived, since it implicitly involves the incongruity that y and z are different for the different stars. I think we may legitimately infer that, whatever the degree of indeterminateness in the aberration by this series, it does not extend to permitting a value so great as 20″.500, for instance. Thus, if we introduce this value in (b) we get $y = +0''.173\ -1.17\,z$; which introduced in (a) gives $\eta = +0''.125\ -0.704\,z$, $\zeta = -0''.039\ +0''.430\,z$. If z is taken within the limits $+0''.05$ and $-0''.05$, we shall have G' between 281° and 291°, and r_2 between 0″.09 and 0″.17. Now the various other investigations show that G' is probably between 300° and 360°, and that r_2 is probably not over 0″.20. By similar reasoning it will be manifest that Struve's observations are incompatible with an aberration larger than 20″.500, and probably with any over 20″.490. This is as far as legitimate deduction can go, it seems to me, until we know more precisely the law governing the constants of the latitude-variation.

As a matter of interest I give the values of the aberration deduced from the observations 1840–42 for the several stars, by means of (36), with the values of Y and Z on p. 58, and $y = +0''.054$, $z = -0.055$, $\eta = +0.042$, $\zeta = -0.065$. Struve's values are given in the last column.

	Present Discussion	Struve
	″	″
υ Ursae Majoris,	20.436	20.457
ι Draconis,	.472	.479
o^2 *Draconis*,	.434	.404
β Cassiopeae,	.429	.423
δ Cassiopeae,	.520	.456
b Draconis,	.546	.504
2 Hev. *Cephei*,	20.375	20.395

In the column v, of Table V, are given the residuals (O—C) which result from the substitution of the aberration 20″.464, the latitude-variation

$$\varphi_0 - \varphi = 0''.077 \cos(t - 2\,394\,108) \times 0^\circ.835 + 0''.081 \cos(\odot - 322^\circ.0)$$

and the corrections to the various declinations. *υ Ursae Majoris* +0″.083, *ι Draconis* —0″.200, *o² Draconis* —0″.051, *β Cassiopeae* +0″.001, *δ Cassiopeae* —0″.016, *b Draconis* +0″.029, 2 Hev. *Cephei* +0″.004. These were derived from the observations 1840–42 alone.

The present investigation seems to throw doubt upon a point to which STRUVE attached considerable importance, namely, that the observations of *β* and *δ Cassiopeae* have a larger probable error than the others. I give in the table below for the observations 1840–42, for each star; the number of the equations, m; the mean error of an equation of the weight unity, ε, the number of unknown quantities being taken as 5; the average number of observations, n; and the probable errors of a single observation, r; with STRUVE's values in the last column.

	m	ε	n	r	STRUVE
		″		″	″
υ Ursae Majoris.	18	±0.236	4.0	±0.080	±0.110
ι Draconis	19	.235	3.2	.088	.127
o² Draconis	15	.295	2.8	.119	.126
β Cassiopeae	16	.197	2.3	.087	.145
δ Cassiopeae	20	.344	1.9	.168	.178
b Draconis	10	.297	2.4	.129	.116
2 Hev. *Cephei*	7	±0.223	2.0	±0.101	±0.089

The present series constitutes the basis of NYRÉN's well-known determination of the nutation-constant, and the present discussion cannot be considered complete without giving the nutation which will result after the elimination of the latitude-variation. It is unnecessary to give details. Employing the residuals v of Table V for the three stars *υ Ursae Majoris*, *ι* and *o² Draconis*, including the corresponding equations for O. STRUVE's and OOM's observations to 1862, we solve the resulting equations of the form

$$\delta\xi + ir + n = 0.$$

where i is the nutation coefficient, and r is the correction to PETERS's value of the lunar nutation 9″.2235. Giving equal weight to the observations before and after 1842, we get the following values of r, by the side of which I place the results of NYRÉN's discussion.

	Wt.	r	NYRÉN
		″	″
υ Ursae Majoris,	29.0	+0.0325	+0.0496
ι Draconis,	71 5	+0.0328	+0.0083
o² Draconis,	24.7	+0.0244	+0.0100
Mean		+0.0311 ·	+0.0224

As was to be expected, from the nature of things, there is no very significant difference in the mean results, except that the values for the three stars are now in better accord. This is satisfactory, so far as it goes, but I do not regard the correction to PETERS's result as real. It seems rather to be merely an effect of the existence of a long-term period in the latitude heretofore alluded to, and which, if it exists, would confound itself with the nutation in a long series of prime vertical observations, in case the periods were approximately the same. But, as heretofore stated, the discussion of this matter is adjourned for the present.

TABLE V. STRUVE'S PRIME-VERTICAL OBSERVATIONS, 1840–55.

t	w	n	v
υ Ursae Majoris.		″	″
40 May 4	4	—.04	+.14
17	3	—.02	+.14
30	3	—.07	+.08
Oct. 4	4	—.20	—.21
30	4	.00	.00
41 Mar. 30	4	—.14	—.01
Apr. 22	5	—.01	+.12
May 6	7	—.13	.00
28	7	—.20	—.08
Oct. 2	3	—.07	—.01
30	4	—.14	—.08
Dec. 23	3	—.19	—.12
42 Jan. 14	4	—.06	+.02
Mar. 11	1	+.12	+.20
May 2	4	—.04	+.02
13	4	—.20	—.14
26	4	—.06	.00
Oct. 16	3	+.05	+.16
43 Apr. 25	3	—.11	—.07
45 May 10	3	—.21	—.10
22	4	—.09	.00
46 May 17	7	—.14	+.02
47 May 21	3	—.18	—.03
υ Ursae Majoris. — Cont.		″	″
48 Apr. 28	2	+.01	+.12
May 13	3	+.02	+.13
49 May 8	4	—.08	—.04
22	5	—.04	—.01
28	5	—.04	—.01
51 May 14	2	+.02	+.09
52 May 25	6	—.23	—.12
53 May 27	7	—.20	—.05
54 May 24	4	—.21	—.08
55 May 31	3	—.18	—.12
[*wnn*], [*wvv*]		2.46	1.04
ι Draconis.		″	″
40 June 6	1	+.46	+.31
26	3	+.29	+.11
July 14	1	+.08	—.12
29	8	+.20	—.02
Aug. 23	6	+.14	—.10
Nov. 2	2	+.10	—.17
17	1	—.03	—.29
41 Jan. 31	2	+.22	+.02
Feb. 22	2	+.26	+.08
ι Draconis. — Cont.		″	″
41 Mar. 16	2	+.34	+.16
May 27	5	+.29	+.13
Aug. 16	5	+.20	+.01
Nov. 5	3	+.30	+.10
Dec. 17	1	+.08	—.12
42 Jan. 25	1	+.45	+.24
Mar. 18	3	.00	—.22
May 17	5	+.20	—.04
Aug. 8	7	+.24	+.03
22	2	+.16	—.03
43 Aug. 8	8	+.38	+.10
44 Aug. 7	1	+.40	+.07
20	2	+.45	+.13
Sept. 5	3	+.24	—.06
45 July 26	3	+.33	+.01
Aug. 3	3	+.33	.00
46 Aug. 2	8	+.30	+.04
47 Aug. 23	2	+.07	—.15
Sept. 14	2	+.17	—.10
48 Aug. 6	2	+.13	—.06
26	2	+.27	+.08
Sept. 4	2	+.26	+.08
49 Aug. 5	3	+.38	+.14
ι Draconis. — Cont.		″	″
49 Aug. 23	4	+.22	.00
50 Aug. 11	3	+.13	—.17
21	2	+.18	—.11
51 Aug. 3	5	+.30	—.04
17	3	+.14	—.20
52 July 16	2	+.16	—.12
28	3	+.16	—.14
Aug. 9	3	+.29	—.02
53 Aug. 8	2	+.36	+.11
22	3	+.18	—.08
54 July 27	4	—.10	—.28
Aug. 7	4	+.03	—.16
55 Aug. 30	1	+.15	—.04
Sept. 22	1	—.19	—.36
[*wnn*], [*wvv*]		8.89	2.02
o² Draconis.		″	″
40 Oct. 1	7	—.06	—.18
25	1	+.13	+.02
41 Feb. 16	1	—.02	—.06
Mar. 30	1	—.05	—.08
Apr. 17	2	+.06	+.03

t	w	n	v
o² Draconis. — Cont.			
		″	″
41 May 9	1	+.40	+.37
July 19	6	+.15	+.11
Oct. 10	2	+.36	+.31
Nov. 4	3	+.14	+.10
Dec. 18	1	+.13	+.09
42 Jan. 13	4	+.02	—.03
Mar. 18	1	—.16	—.24
Apr. 13	6	+.04	—.05
26	2	—.12	—.22
Oct. 14	4	+.08	+.09
44 Oct. 18	2	+.11	+.04
Nov. 1	2	—.06	—.10
45 Nov. 10	4	.00	—.09
46 Nov. 8	3	+.13	+.01
47 Nov. 10	1	—.02	—.10
48 Oct. 19	3	+.01	—.01
Nov. 20	1	+.28	+.27
Dec. 9	1	—.20	—.21
49 Oct. 20	4	—.12	—.11
50 Nov. 15	1	—.15	—.13
Dec. 2	3	—.07	—.02
[*wnn*], [*wvv*]		1.07	1.12

t	w	n	v
β Cassiopeae.			
		″	″
41 May 29	3	—.13	—.11
June 18	3	+.08	+.09
Oct. 4	1	+.15	+.14
Nov. 2	2	+.16	+.16
29	1	+.13	+.15
Dec. 18	1	—.07	—.05
42 Jan. 7	1	—.14	—.12
14	4	—.03	.00
Feb. 12	2	—.24	—.22
Mar. 18	1	—.28	—.29
Apr. 2	2	—.08	—.11
16	3	—.24	—.28
June 5	4	+.19	+.13
22	2	—.10	—.15
Oct. 17	5	+.20	+.25
Dec. 12	2	—.10	—.01
[*wnn*], [*wvv*]		0.94	0.43
δ Cassiopeae.			
		″	″
41 Feb. 1	1	+.04	+.05
Apr. 28	1	—.25	—.24
May 29	2	—.22	—.22

t	w	n	v
δ Cassiopeae. — Cont.			
		″	″
41 June 18	2	+.16	+.14
28	3	+.20	+.18
Nov. 2	1	+.25	+.24
29	1	+.33	+.33
Dec. 18	1	—.10	—.10
42 Jan. 13	5	—.13	—.13
Feb. 12	2	—.16	—.16
Mar. 21	1	—.22	—.25
Apr. 2	1	—.41	—.45
16	2	—.35	—.40
June 5	1	+.09	+.02
22	2	—.10	—.18
July 3	2	+.36	+.28
Oct. 14	3	+.25	+.27
24	3	+.20	+.23
Dec. 4	2	—.05	+.02
17	1	—.11	—.03
[*wnn*], [*wvv*]		1.70	1.78
b Draconis.			
		″	″
40 Aug. 6	7	—.02	—.02
Sept. 7	1	—.14	—.17

t	w	n	v
b Draconis. — Cont.			
		″	″
40 Sept. 26	4	—.04	—.08
Oct. 4	3	—.15	—.19
41 Mar. 16	1	+.10	+.15
Apr. 14	1	+.09	+.11
May 9	1	+.25	+.30
Sept. 6	3	+.18	+.22
Oct. 6	1	—.07	—.04
42 Apr. 6	2	+.02	+.01
[*wnn*], [*wvv*]		0.28	0.41
2 Hev. *Cephei.*			
		″	″
40 Nov. 1	2	—.08	—.13
41 Mar. 30	1	—.08	—.05
May 9	1	+.11	+.13
Nov. 4	3	+.11	+.13
42 April 14	3	—.09	—.13
25	1	—.09	—.13
Oct. 14	3	+.05	+.11
[*wnn*], [*wvv*]		0.11	0.10

OBSERVATIONS OF COMETS 1892 III AND *g* 1892,

MADE AT GOODSELL OBSERVATORY, NORTHFIELD, MINN., WITH THE 16-INCH REFRACTOR AND FILAR-MICROMETER.

By H. C. WILSON.

[Communicated by Wm. W. Payne, Director.]

1893 Northfield M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
Comet 1892 III (Holmes).								
h m s			m s	′ ″	h m s	° ′ ″		
Jan. 30 7 4 58	1	9 . 6	+0 18.12	—1 17.8	1 41 24.86	+33 45 37.7	9.422	0.327
Feb. 4 7 25 56	2	9 . 6	+1 25.90	—6 12.4	1 48 52.73	+35 52 5.0	9.511	0.382
14 8 20 34	3	9 . 6	+2 50.22	+0 49.4	2 4 35.24	+34 10 9.2	9.642	0.517
8 20 34	4	9 . 6	+2 38.51	+1 8.8	2 4 35.04	+34 10 10.9	9.612	0.517
16 6 52 45	5	10 , 6	+0 2.20	+6 57.9	2 7 12.69	+34 14 22.5	9.502	0.361
Mar. 11 8 25 48	6	5 . 6	+0 28.14	+1 21.1	2 46 47.60	+35 13 43.2	9.697	0.610
Comet 1893 I (*g* 1892 Brooks).								
Feb. 14 7 36 45	7	9 . 6	+0 26.68	+1 47.4	0 19 59.87	+27 30 53.2	9.661	0.671

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 41 7.65	—0.91	+33 46 47.3	+8.2	Leiden A.G. Zones 393.32 ; 397,26
2	1 47 27.90	—0.97	+33 58 9.2	+8.1	" " " 396.12 ; 398,27
3	2 1 46.05	—1.03	+34 9 11.9	+7.9	" " " 260.18 ; 337,13
4	2 1 57.56	—1.03	+34 8 54.2	+7.9	" " " 397,42 ; 398,28
5	2 7 41.52	—1.03	+34 7 16.6	+8.0	" " " 239.3 ; 333,109
6	2 46 20.61	—1.15	+35 12 14.3	+7.8	" " " 251,34 ; 329,87
7	0 19 34.65	—1.46	+27 29 5.9	+0.1	Paris 441

Notes on Comet 1892 III (Holmes).

Jan. 30. Comet very faint in moonlight, yet visible in the finder. In the large telescope the coma was about 2′ in diameter, slightly condensed in center, but with no definite nucleus. A faint tail could be traced to the edge of the field (5′) in p.a. 45°. At moments I thought I caught a glimpse of a nucleus, but it was not brighter than 12M.5.

Feb. 4. Comet quite bright in the 5-inch finder, and oval in shape, with eccentric condensation. In the large telescope the head of the comet is about 3′ in diameter, with a tail 10′ long. There is a strong condensation, but no definite nucleus, except at moments when a sharp point about 14M is glimpsed.

Feb. 14. Easily seen in finder. About 5′ in diameter, with tail 25′ long. In the large telescope no nucleus could be seen, and the central condensation was at first large and diffuse. Later it became more condensed and easier to bisect.

Feb. 16. Very easily seen in finder, about 10′ in diameter, with a tail 30′ long. In the large telescope no nucleus could be seen, but there was a slight condensation in the nebulosity, which was bisected in the observations. The comet is again getting to be a difficult object for micrometrical measurement.

March 11. Very faint. About 1′ in diameter, with very slight central condensation. Too faint for $\Delta\alpha$ by transits. $\Delta\alpha$ measured with the micrometer, the light being reduced to a minimum, and alternately turned on and off. Not visible in 5-inch finder.

April 3. Found Holmes's comet in place, but it was exceedingly faint, and impossible to observe micrometrically. It was, perhaps, 2′ in diameter, with very slight condensation in center.

Note on Comet 1893 I (*g* 1892 Brooks).

Feb. 14. Faint and very small in 5-inch. In 16-inch about 1′ in diameter, with short tail. Strong condensation about nucleus, which last is not very well defined.

Note on Comet 1892 I (Swift).

Feb. 14. Found a very faint object in the proper position, but there was no comparison-star near, so that the position could not be determined accurately.

Corrigendum.

In *Astr. Journ.*, no. 289, p. 8, the declination of comparison-star No. 11 should be +53° 17′ 17″.6, instead of +53° 13′ 45″.9, and the corresponding declination of Comet *g* 1892 on Jan. 16 should be +53° 18′ 59″.8, instead of +53° 15′ 28″.1.

STARS THAT HAVE BEEN FOUND VARIABLE IN THE PHOTOGRAPH,

By WM. MAXWELL REED.

[Communicated by Prof. E. C. Pickering, Director of Harvard College Observatory.]

The following observations were made by relative eye-estimation with the 6¼-inch Clacey Equatorial. They were undertaken to confirm visually the photographic discoveries of variability in certain stars. The reduction of the observations has therefore been merely approximate. For the values of the comparison-stars, the DM. magnitudes have been used.

DM. 39°4851.

Announced by Mrs. Fleming in *A.N.*, 128, p. 121. The variations of this star seems well established. But unfortunately the observations are not sufficiently extensive to give even an approximate period.

	M	
1891 July 17	8.5	
July 27	8.4	
Sept. 2	10.5	(circum.)
Sept. 24	10.0	invisible
1893 Nov. 3	7.6	
Dec. 9	10.0	(circum.)

DM. 54°431.*

Announced by Mrs. Fleming in *A.N.* 126, p. 165. The following observations confirm the variability of this star, and indicate a period of little less than one year.

	M		M
1891 Aug. 20	8.3	1892 Jan. 21	<10
Sept. 2	8.2	Mar. 5	<10
Sept. 24	8.1	Apr. 6	8.8
Oct. 16	8.2	Oct. 28	8.7
Nov. 2	8.6	Nov. 10	9.3
Nov. 18	7.5	Nov. 16	9.7

DM. 53°2684.†

Mr. Espin published a note upon this star in *A.N.* 126, p. 111. The following observations confirm variability, and give evidence that the period will prove to be about a year.

	M		M
1891 May 28	8.2	1891 Nov. 2	8.6
June 9	8.4	Nov. 18	8.8
June 15	7.7	1892 Apr. 13	8.2
June 23	8.0	May 16	7.6
July 9	8.1	Oct. 28	8.5
Aug. 20	8.9	Nov. 3	8.4
Sept. 2	9.1	Dec. 9	8.9

S.DM. −5°4858.*

Photographic observations on this star were published in *A.N.* 126, p. 165, by Mrs. Fleming. The following observations verify Mrs. Fleming's conclusion that the star is variable with small range.

	M		M
1891 May 28	7.1	1891 Aug. 20	6.4
June 9	7.1	Sept. 2	6.4
June 15	7.2	Sept. 24	6.5
June 23	6.8	1892 Mar. 6	7.2
July 9	7.1	Mar. 25	6.4
July 25	6.5	Nov. 3	6.3
July 27	6.7		

DM. 62°596.

An exceedingly red star, fully 9 on Mr. Chandler's scale of redness. In *A.N.* 127, p. 5, Mrs. Fleming published some photographic observations on this star, which had a range of 1.4 magnitudes. The following visual estimates, however, indicate no change in the light of the star during the period covered by the observations. Through the kindness of Mr. Wendell the writer is able to publish some observations made in 1887, which confirm the above conclusion. In a recent number of this Journal Mr. Yendell also fails to find evidence of variation in this star. Mr. Wendell's comparison-stars were 62°590, 62°593. The writer's were 63°451, 63°436. The constant difference between the two series of observations is not surprising when we consider the redness of the variable, and the difference in the instruments. Mr. **Wendell** used the 15-inch equatorial, except for the first observation of Oct. 21, 1887, when he used the 4-inch finder.

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* 678 *U Persei*. See *A.J.* XII, 113; XIII, 13.

† 7783 *RU Cygni*. See *A.J.* XII, 114; XIII, 13.

* 6834 *V Aquilae*. Sawyer, *A.J.* XIII, 13; confirmed by Yendell, *ibid*.

		M	Observer			M	Observer
1887	Sept. 8	8.6	O.C.W.	1891	Sept. 2	7.9	W.M.R.
	Sept. 10	8.5	"		Sept. 24	7.6	"
	Sept. 15	8.7	"		Oct. 16	7.6	"
	Oct. 12	9.0	"		Nov. 2	7.6	"
	Oct. 21	8.6	"				
	Oct. 21	8.7	"				

		M	Observer	
1891	Nov. 18	7.8	W. M. R.	6¼-inch
1892	Jan. 21	7.9	"	"
	Feb. 17	7.7	"	"
	Mar. 5	7.8	"	"
	Apr. 1	7.6	"	"
	Apr. 12	7.5	"	"
	May 16	7.6	"	"
	Oct. 28	7.6	"	"
	Nov. 3	7.8	"	"
	Nov. 10	7.7	"	"
	Nov. 16	7.7	"	"

Cambridge, Mass., 1893 *March* 22.

The writer has examined the plates from which Mrs. **Fleming** inferred that the star is variable, and wishes to confirm her statement that the photographic images of this star show large variations relative to the surrounding stars.

$20^{h}\ 43^{m}.1 \quad +18^{\circ}\ 58' \quad (1900).$

Announced variable in *A.N.* 127, p. 5, by Mrs. **Fleming**. With the exception of June 23, the following observations give no satisfactory confirmation of variation in this star. In the photograph, however, the star appears subject to very large fluctuations in light.

		M			M
1891	May 28	9.2	1891	July 27	9.2
	June 9	9.1		Aug. 20	not seen*
	June 15	9.0		Sept. 2	9.4
	July 9	9.0	1892	Nov. 3	9.0

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* Notes in the record for this observation are: "Moonlight very bright, stars of the 10th magnitude, invisible."

ON THE VARIABILITY OF THE STAR (2258) *AURIGAE*,

BY PAUL S. YENDELL.

This star is included in **Chandler**'s "List of Stars Probably Variable," in the Supplement to his Catalogue.

I have observations as follows:

1892			1892, 93		
		M			M
Jan.	1,	10.5 hazy	Nov.	20,	10.0
Mar.	5,	not seen; moon 1st qu.	Dec.	9,	9.9
Apr.	19,	not seen		16,	10.1
	24,	not seen; limit $<11^{M}.0$	Feb.	5,	10.1
Oct.	21,	$10^{M}.1$	Apr.	3,	not seen } limit
	23,	$9^{M}.9$		9,	" " } $<11^{M}.5$
Nov.	11,	$10^{M}.0$			

Up to the third of this month, I considered that my observations furnished no proof of the star's variability, the failures to see it during the spring of 1892, being thought to be very possibly due to a failure to locate the star, which is at all times faint in my telescope, and the field at that time still unfamiliar; the latter, however, was certainly not the case this spring, and I have now no doubt that the star is variable.

Espin, who first suggested its variability, says, in *Nature* for March 30, 1893, it was $10^{M}.5$ on March 20, and is variable.

My observations furnished no data for determining an epoch of maximum, but the minima would seem to recur at intervals of not far from a year, and the star's variations may be similar to those of 7242 *S Aquilae*. It is too faint for any color to be recognizable with my telescope.

Dorchester, Mass., 1893 *April* 15.

SYSTEMATIC CORRECTION OF THE DECLINATIONS OF THE *FUNDAMENTAL-CATALOG* FOR VARIATION OF LATITUDE,

BY S. C. CHANDLER.

In the article on the influence of latitude-variations upon astronomical constants and measurements (*A.J.* 284), it was pointed out that there must exist, in all catalogues of fundamental declinations, a systematic error arising from this cause, varying with the right-ascension.

The highly important function of **Auwers**'s *Fundamental-Catalog* in the reduction of the zone catalogues of the *Astronomische Gesellschaft*, and many other differential series of meridian observations, attaches special interest to the question, what are the corrections to the equator-points which it gives? Fortunately the answer is now very simple and certain. The basis of this system in declination, for the epoch of the modern observations used in its construction, is the catalogue formed by **Nyrén** from the vertical-circle observations of 1863-75. In *A.J.* 293, §§ 4 and 5, I have found the corrections for latitude according to this series, in equations (41) and (42). Combining by weights,

$$\varphi-\varphi_0 = -0''.204\cos(t-1870\ \text{Feb. }23)\times 0^{\circ}.843 \\ -0''.131\cos(\odot-309^{\circ}.8)$$

The corrections by this formula were computed for the individual observations in vol. XIV of the Pulkowa Annals, pp. (57)-(83), and the means taken for the several stars. The lower culminations were included above 50° declination, and the incomplete observations (East or West alone) within 5° of the zenith; agreeably to Nyrén's description of the formation of his catalogue (*A.G.Publ.*XIV). Collecting the results by hours of R.A. and zones of declination, we have the mean results of the following table.

The weighted means for all of the 336 stars in each hour are given in the sixth column, +90°—10°. These are very closely represented by the formula

$$-0''.007 + 0''.088 \sin(\alpha+153°)$$

as is shown in the last two columns. The different zones are clearly in substantial accord. The polar zone gives a perceptibly smaller range than the others, for the manifest reason that the combination of the two culminations tends to eliminate the error due to the latitude-variation.

We conclude with certainty, then, that the Pulkowa system is farther north at 8^h by nearly a fifth of a second than it is at 20^h; in other words, that its equator intersects the true one at 2^h and 14^h at an angle of half this amount. In reducing meridian-circle observations, therefore the equator-points found from *B.J.* stars require correction by the above formula, whose values are given in the "computed" column, for the middle of each hour of right-ascension. It also follows that all the catalogues of the *Astron. Gesellschaft* are subject to this correction.

Pulkowa Vertical-Circle Declinations (1863-75) of 336 Hauptsterne.

Correction for Latitude-Variation.

R.A.	90° —50°		50° —30°		30° —10°		10° —10°		+90° —10°		Comp.	O—C
h	″		″		″		″		″		″	″
0	+0.03	6	+0.03	3	—0.00	4	+0.08	2	+0.029	15	+0.022	+0.007
1	.00	5	— .07	3	— .03	6	— .04	3	— .031	17	.000	— .031
2	— .01	5	— .02	3	+ .02	2	— .07	7	— .032	17	— .023	— .009
3	— .01	1	— .01	9	— .02	5	+ .06	4	+ .002	19	— .045	+ .047
4	— .06	2	— .13	5	— .12	4	— .07	4	— .104	15	— .064	— .040
5	— .10	1	— .10	4	— .10	2	— .10	14	— .098	21	— .079	— .019
6	— .02	1	— .19	1	— .12	7	–	–	— .115	9	— .089	— .026
7	— .02	1	— .10	1	— .09	5	— .11	2	— .086	9	— .095	+ .009
8	— .03	1	+ .04	3	+ .02	3	— .01	4	+ .010	11	— .093	+ .103
9	— .08	5	— .08	2	— .05	3	— .09	2	— .074	12	— .086	+ .012
10	— .07	2	— .03	3	— .01	3	— .12	1	— .043	9	— .074	+ .031
11	.00	2	— .07	4	— .10	4	— .17	3	— .093	13	— .056	— .037
12	— .04	4	— .13	1	— .01	1	— .10	3	— .067	9	— .036	— .031
13	— .07	1	+ .02	1	— .01	3	+ .03	2	.000	7	— .014	+ .014
14	+ .01	4	+ .07	4	— .02	3	+ .03	5	+ .025	16	+ .009	+ .016
15	+ .04	3	.00	6	+ .02	7	+ .03	4	+ .019	20	+ .031	— .012
16	+ .02	4	+ .03	6	+ .02	2	+ .08	4	+ .038	16	+ .050	— .012
17	.00	6	+ .03	3	+ .14	5	+ .14	4	+ .075	18	+ .065	+ .010
18	+ .05	3	+ .05	5	+ .03	4	+ .04	3	+ .048	15	+ .075	— .027
19	+ .04	7	.00	1	+ .03	5	+ .04	5	+ .052	18	+ .081	— .049
20	+ .04	2	+ .09	5	+ .08	5	— .03	2	+ .061	14	+ .081	— .020
21	+ .02	2	+ .15	3	+ .15	2	+ .16	4	+ .130	11	+ .072	+ .058
22	+ .04	3	+ .08	4	+ .06	7	+ .09	4	+ .067	18	+ .060	+ .007
23	+0.02	1	+0.08	3	–	–	+0.03	3	+0.051	7	+0.042	+0.009
All		72		83		92		89		336		

Cambridge, 1893. *April*.

NEW ASTEROID.

Professor Krueger has sent notice of the photographic detection of another by Dr. Wolf, at Heidelberg, April 14, in the position

1893 *Y* 13ᴹ April 14 12^h Heidelberg M.T. $\alpha = 13^h\ 24^m\ 24^s$, $\delta = -8°\ 33'$. Daily motion, -44^s and 2′ northward.

The planet 1893 *Q* appears to be identical with no. 104 *Clymene*, thus giving, as the correction to the Ephemeris in the Berlin *Jahrbuch*, $\Delta\alpha = +5^m$, $\Delta\delta = -33'$.

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ON THE CONSTANT OF ABERRATION,

By S. C. CHANDLER.

IV.

§7. Nyrén's Prime-Vertical Observations, 24 Stars, 1879–82.

Nyrén's Prime-Vertical observations, which form altogether the finest contribution to the knowledge of the aberration-constant in the annals of astronomy, have been treated here in two parts, for the following reason. After the discussion of the observations of 1880–82 had been completed and placed in the hands of the printer, exactly as it stands in this section, Prof. Newcomb kindly sent me a series of observations on four stars, in the years 1875–79, hitherto unpublished, and which had been communicated to him by Dr. Nyrén, Vice-Director of the Pulkowa Observatory, with full permission to make any use of them he pleased. I desire to thank both of these gentlemen for the opportunity thus afforded of discussing this new material in the same way as the rest. The results will be given in §8.

The observations have been employed exactly as given by Nyrén in his well-known Memoir of 1883, the values of n, pp. 12–34, being written with the opposite sign, to conform to our present notation. Two obvious misprints were corrected, it being evident from an examination of his equations that the observations of *χ Cassiopeae* 1881 Aug. 20, and of *θ Draconis* 1880 Mar. 16, were used by him as having a weight of $\frac{1}{2}$.

Grouping the observations, we have the values of n in Table VI. If the material permitted, these would be solved according to eq. (35). Since the series extends only from 1879 Dec. 17 to 1882 Jan. 29, however, it is manifestly too short to give determinately the coefficients of both terms of the latitude-variation. Two courses then are open: (a) to find Y and Z in terms of y and z, as has been done in Struve's series, and then to substitute values of y and z from extraneous sources; (b) to correct the values of n for the 427-day term, and then solve only for the other unknowns. The first method, which is very laborious with so many stars, is in the present case entirely unnecessary. It is *a priori* evident, from the nearly uniform distribution of Nyrén's stars in right-ascension, that the value of the aberration will be almost entirely independent of the particular values of the constants assumed for either term of the latitude-variation, since the effect of error in the assumptions will be compensated in the resulting values for the constants of the other term; *i.e.*, the sum of the two terms, or the resultant total effect of the latitude-variation, will be practically unaffected. Some preliminary solutions were made which completely verified this conclusion. I therefore employed the method (b) without hesitation. The values of n, then, were corrected for the 427-day term by taking $r_1 = 0''.125$, $T_1 = 2\,406\,191$, $\theta = 0°.843$, according to eq. (18), *A.J.* 277. Putting $\lambda = -30°.3$ in (23) we have the first term of (24), $\varphi_0 - \varphi = +0''.125 \cos(t - 2\,406\,227) \times 0°.843$. Adding this to n in Table VI, we have the values n', which are to be solved according to eq. (35) omitting the terms in y and z, or by

$$X + Y \sin\odot + Z \cos\odot = n'$$

Since it would require too much space to write the normal equations for 24 stars in the ordinary way, I tabulate the various coefficients, which will serve the same purpose. Putting $a = 1$, $b = \sin\odot$, $c = \cos\odot$, we have:

		$[paa]$	$[pab]$	$[pac]$	$[pan']$ ″	$[pbb]$	$[pbc]$	$[pbn']$ ″	$[pcc]$	$[pcn]$ ″
1	*β Cassiopeae*,	+26.00	+ 3.61	— 1.99	—0.32	+15.27	— 9.42	+1.49	+10.74	+0.03
2	*δ Cassiopeae*,	+42.00	+ 0.69	—12.16	—0.45	+24.47	—13.54	+4.45	+17.43	—2.88
3	*χ Cassiopeae*,	+21.50	+ 0.34	—10.42	+0.81	+ 8.02	— 5.47	+2.68	+13.39	—2.21
4	2 H. *Camelopardalis*,	+22.00	— 1.26	— 2.89	+1.04	+ 4.83	— 7.24	+1.26	+17.20	—3.22
5	10 H. *Camelopardalis*,	+11.00	— 2.88	— 3.86	+0.64	+ 1.86	— 0.91	+0.30	+ 9.14	—1.92
6	DM. 793	+21.00	— 8.64	— 1.74	—0.60	+ 5.45	— 3.59	+0.83	+15.55	—2.25
7	11 *Camelopardalis*,	+22.00	— 6.93	— 2.75	—0.09	+ 2.95	— 1.67	+0.16	+19.08	—0.34
8	37 *Camelopardalis*,	+15.50	— 5.50	+ 5.39	—0.46	+ 3.52	+ 1.08	—0.01	+11.98	—0.78

		[paa]	[pab]	[pac]	[pan'] ″	[pbb]	[pbc]	[pbn'] ″	[pcc]	[pcn] ″
9	2 *Lyncis*,	+24.00	— 5.67	+ 5.17	—0.35	+ 2.39	— 2.52	+0.40	+21.61	—1.40
10	14 *Lyncis*,	+23.50	— 6.58	+11.84	+0.02	+ 5.39	+ 2.14	—0.27	+18.13	—0.84
11	15 *Lyncis*,	+30.00	— 9.42	+15.63	—1.61	+ 5.81	— 1.87	+0.94	+24.19	+0.63
12	24 *Lyncis*,	+32.50	— 4.67	+18.97	—1.51	+ 4.74	+ 4.14	+0.30	+27.77	—0.80
13	υ *Ursae Majoris*,	+31.00	+ 4.07	+14.78	—0.42	+19.79	+ 6.77	—1.29	+11.27	+0.03
14	74 *Ursae Majoris*,	+18.00	+ 3.17	+10.06	—0.72	+12.37	+ 1.96	—0.71	+ 5.67	—0.42
15	75 *Ursae Majoris*,	+10.00	+ 1.42	+ 5.74	—1.20	+ 6.70	+ 1.12	—0.45	+ 3.32	—0.73
16	Radcliffe 3104	+ 9.00	+ 1.80	+ 5.71	—0.72	+ 5.18	+ 0.45	+0.20	+ 3.82	—0.53
17	ι *Draconis*,	+41.00	+ 8.73	+ 4.09	+0.30	+ 6.19	— 4.72	—0.32	+34.81	+3.17
18	θ *Draconis*,	+32.50	+ 7.23	+ 0.58	+1.02	+ 4.03	— 3.61	+0.24	+28.47	+1.85
19	*b Draconis*,	+36.50	+12.66	— 0.39	+0.89	+ 7.03	+ 5.00	+0.92	+29.47	+2.69
20	ο *Draconis*,	+41.00	+ 8.99	— 4.22	+0.75	+ 8.83	+ 5.85	—0.18	+32.17	—0.35
21	Radcliffe 4511	+15.00	+ 3.88	— 7.90	+0.57	+ 7.13	+ 2.18	—0.28	+ 7.87	—0.33
22	Radcliffe 5074	+ 9.50	— 0.08	— 5.51	+0.25	+ 6.03	+ 1.21	+0.59	+ 3.46	—0.11
23	B.A.C. 7387	+11.00	+ 0.47	— 6.09	+0.43	+ 7.28	+ 1.13	+0.29	+ 3.72	—0.42
24	15 *Cephei*,	+ 6.00	+ 0.30	— 3.72	+0.21	+ 3.66	+ 0.12	+1.02	+ 2.31	—0.06

The solution gives.

	X ″	Y ″	w_1	Z ″	w_2
1	— 0.029	+ 0.224	6.87	+ 0.194	4.93
2	— .038	+ .135	11.66	— .087	6.63
3	+ .027	+ .326	4.64	— .011	4.83
4	+ .012	— .025	1.50	— .194	5.30
5	+ .009	+ .079	0.63	— .198	4.45
6	— .079	— .086	0.69	— .173	5.62
7	+ .060	+ .199	0.42	+ .008	10.36
8	— .001	+ .016	0.68	— .066	4.39
9	+ .053	+ .241	0.97	— .049	18.89
10	+ .090	+ .106	1.10	— .118	3.78
11	— .092	+ .068	2.28	+ .079	12.81
12	— .034	+ .040	1.24	— .012	5.11
13	— .085	— .109	13.73	+ .179	3.01
14	+ .075	— .046	11.10	— .192	0.05
15	— (.116)	— (.043)	2.86	+ (.004)	0.01
16	+ .066	+ .036	2.41	— .242	0.10
17	— .010	+ .037	3.42	+ .097	27.19
18	+ .001	+ .131	1.93	+ .082	22.69
19	— .003	+ .081	1.74	+ .078	19.47
20	+ .030	— .053	5.41	+ .003	25.04
21	+ .289	— .297	1.32	+ .330	0.80
22	+ (.050)	+ (.106)	0.87	+ (.040)	0.04
23	+ (.056)	+ (.052)	1.73	+ (.035)	0.08
24	+0(.037)	+0(.277)	20.05	+0(.026)	0.02

The substitution of the unknowns in the observation-equations gives the value of v_1 in table VI. In four of the stars the solution was indeterminate as regards Z, as is shown by its small weight, w_2, in the table. For these I determined Y in terms of Z, and then substituted a value of Z found from the second of (28), using approximate values of u and ζ found by a preliminary solution of the whole data. The unknowns for these stars are given in parentheses. Practically, however, the effect on the values of η, ζ, and u, is merely nominal, as will be evident from the small weight w_0, in the following equations of condition, formed from the preceding by means of (37).

1	$+0.853\eta$	$+0.198\zeta$	$+0.767u$	$=$	$+0''.229$	$w_0 = 8.8$
2	$+ .813$	$- .063$	$+ .665$	$=$	$+ .115$	$= 17.5$
3	$+0.786$	-0.071	$+0.623$	$=$	$+ 0.257$	$= 7.5$
4	$+0.556\eta$	-0.402ζ	$+0.471u$	$=$	$+ 0''.064$	$w_0 = 4.2$
5	$+ .445$	$- .464$	$+ .413$	$=$	$+ .127$	$= 2.8$
6	$+ .388$	$- .501$	$+ .401$	$=$	$+ .054$	$= 3.8$
7	$+ .236$	$- .548$	$+ .356$	$=$	$+ .043$	$= 6.2$
8	$+ .002$	$- .581$	$+ .338$	$=$	$+ .038$	$= 13.0$
9	$- .034$	$- .581$	$+ .339$	$=$	$+ .020$	$= 52.8$
10	$- .159$	$- .576$	$+ .357$	$=$	$+ .051$	$= 9.1$
11	$- .174$	$- .559$	$+ .342$	$=$	$- .056$	$= 26.7$
12	$- .338$	$- .517$	$+ .381$	$=$	$- .008$	$= 6.9$
13	$- .712$	$- .245$	$+ .567$	$=$	$+ .034$	$= 17.6$
14	$- .853$	$+ .288$	$+ .811$	$=$	$- .016$	$= 0.6$
15	$- .856$	$+ .287$	$+ .815$	$=$	$+ (.038)$	$= 0.1$
16	$- .768$	$+ .557$	$+ .900$	$=$	$- .163$	$= 0.3$
17	$- .547$	$+ .812$	$+ .958$	$=$	$+ .059$	$= 9.0$
18	$- .429$	$+ .885$	$+ .967$	$=$	$+ .017$	$= 7.7$
19	$+ .083$	$+ ,987$	$+ .981$	$=$	$+ .084$	$= 18.5$
20	$+ .184$	$+ .974$	$+ .983$	$=$	$- .907$	$= 22.6$
21	$+ .402$	$+ .901$	$+ .974$	$=$	$+ .178$	$= 0.9$
22	$+ .597$	$+ .770$	$+ .949$	$=$	$+ (.094)$	$= 0.1$
23	$+ .635$	$+ .737$	$+ .946$	$=$	$+ (.059)$	$= 0.1$
24	$+0.744$	$+0.598$	$+0.912$	$=$	$+0(.122)$	$= 0.1$

From these equations of condition we form the normal equations,

$$\begin{array}{rrrcl} +42.140\eta & + 4.662\zeta & + 8.408u & = & +4''.932 \\ + 4.662 & +93.493 & +27.667 & = & +1.209 \\ + 8.408 & +27.667 & +94.025 & = & +7.174 \end{array}$$

the solution of which gives,

$$\eta = +0''.1043, \quad \zeta = -0''.0130, \quad u = +0''.0709$$

whence result the values of v_2, Table VI. By equation (30) we find, $r_2 = 0''.105$, $G' = 277^\circ.1$: consequently

$$\begin{aligned} \varphi - \varphi_0 = -0''.125 \cos(t-2407935) \times 0^\circ.843 \qquad (45) \\ - 0''.105 \cos(\odot - 277^\circ.1) \end{aligned}$$

the first term being taken as assumed in the previous explanation.

For the aberration we have as the definitive value from this series, **20″.516**

Introducing the values of η and ζ in (36), we get in the column u below the correction to Struve's aberration-constant according to the several stars. By their side are placed Nyrén's values expressed in terms of the unknown parallaxes, from pp. 35, 36 of his memoir.

CORRECTION TO STRUVE'S ABERRATION.

	u	NYRÉN		$O-C$	NYRÉN
	″	″		″	″
1	+0.188	+0.015	+0.88π	+0.117	+0.018
2	+ .047	+ .081	+ .46	— .024	+ .033
3	+ .281	+ .224	+ .73	+ .210	+ .190
4	+ .002	+ .078	+ .49	— .069	+ .031
5	+ .179	+ .181	+ .60	+ .108	+ .140
6	+ .015	+ .041	+ .47	— .056	— .007
7	+ .028	— .148	+ .27	— .043	— .206
8	+ .089	— .018	+ .29	+ .018	— .075
9	+ .044	— .066	— .11	— .027	— .143
10	+ .165	— .004	+ .18	+ .094	— .066
11	— .137	— .288	— .06	— .208	— .362
12	+ .050	— .138	— .14	— .021	— .216
13	+ .182	+ .059	+ .04	+ .113	— .010
14	+ .094	+ .072	— .37	+ .023	— .017
15	+(.178)	+ .052	— .38	+ .107	— .038
16	— .083	— .052	— .51	— .154	— .148
17	+ .133	+ .218	+ .38	+ .062	+ .166
18	+ .077	+ .177	+ .28	+ .006	+ .120
19	+ .092	+ .186	+ .08	+ .021	+ .119
20	— .011	+ .071	+ .05	— .082	+ .003
21	+ .154	+ .042	+ .54	+ .083	— .002
22	+(.046)	+ .103	+ .84	— .025	+ .074
23	+(.005)	+ .016	+ .76	— .066	— .017
24	+(.170)	+0.318	+0.65	+0.099	+0.279

An inspection of these results shows in the most satisfactory manner that the extraordinary systematic anomalies which NYRÉN found have practically disappeared in the new investigation. This will be manifest from the column $O-C$, which gives the deviation of the column u from the mean value +0″.071, and the last column, which gives the corresponding deviation for NYRÉN's values putting 0″.05 as a reasonable assumption for the average value of π. It will be seen that the plus and minus signs alternate quite promiscuously according to our present discussion. The mysterious anomalies found by NYRÉN appear then to have been traced to their true source. It will be recollected that the correction to STRUVE's aberration according to NYRÉN's discussion was $+0''.105 + 0.19\pi_0$. This, by the above assumption as to π_0, would give the aberration-constant 20″.560. Such a value seemed to be so entirely out of character with previous determinations, that NYRÉN felt constrained, in view of the evident presence of an unknown disturbance—and while frankly admitting that the process was an arbitrary one—to take the mean by quadrants, and to ignore the term for the parallax entirely; in other words to call the parallax zero. It is certainly gratifying to find that the results are now harmonious without resorting to arbitrary assumptions or processes, and that we find in this series an additional proof of the correctness of the law of the variation of latitude developed in these papers. I have already (p. 178, vol. XII) alluded to the circumstance that the time chosen for this series was fortuitously favorable to the smallest possible effect of the latitude-variation upon the aberration, since the 427-day and annual terms then nearly nullified each other. A year or two earlier or later they would have been so magnified that it seems impossible that their meaning could have escaped the acuteness of the astronomers at Pulkowa. That they should appear so clearly in the observations of 1880-82 is the best possible testimony to the high character of this beautiful series of observations.

TABLE VI. NYRÉN'S PRIME-VERTICAL OBSERVATIONS OF TWENTY-FOUR STARS, 1879–82.

t	w	n	n'	v_1	v_2
β Cassiopeae.					
1880-81		″	″	″	″
Feb. 23	3	+.16	+.07	+.02	+.18
July 20	1	—.12	.00	—.08	—.11
Aug. 15	7	—.13	—.01	+.05	—.07
Dec. 4	1	—.30	—.32	—.02	—.13
Jan. 17	5	—.15	—.24	—.10	—.06
Feb. 13	2	+.37	+.25	+.25	+.38
June 30	5	+.07	+.08	—.08	—.05
Aug. 5	2	+.01	+.08	+.08	.00
[*wnn*], [*wvv*]		0.71	0.57	0.24	0.46
δ Cassiopeae.					
1879-80-81		″	″	″	″
Dec. 20	5	—.13	—.25	—.08	—.07
Jan. 20	2	—.03	—.15	+.04	+.02
Aug. 3	4	+.15	+.27	+.15	+.16
Aug. 20	10	—.06	+.06	—.05	—.02
Dec. 11	2	—.30	—.33	—.18	—.16
Jan. 17	5	—.09	—.18	+.02	—.01
Feb. 10	3	+.07	—.04	+.15	+.09
June 30	5	—.04	—.02	—.13	—.16
Aug. 17	3	—.04	+.05	—.06	—.04
Sept. 3	3	+.24	+.35	+.26	+.30
[*wnn*], [*wvv*]		0.63	1.44	0.58	0.61
χ Cassiopeae.					
1880-81		″	″	″	″
Feb. 23	3	+.02	—.07	+.05	—.01
Aug. 20	9	.00	+.12	—.09	.00
Dec. 15	3	—.34	—.38	—.08	—.25
Jan. 19	2	—.12	—.21	+.04	—.11
Aug. 23	2½	+.18	+.28	+.09	+.16
Sept. 7	2	+.29	+.40	+.28	+.32
[*wnn*], [*wvv*]		0.63	1.18	0.28	0.46
2 H. *Camelopardalis.*					
1880-81		″	″	″	″
Feb. 19	3	—.15	—.25	—.10	—.19
Mar. 8	2	—.14	—.20	—.03	—.18
Aug. 18	4	+.02	+.14	—.02	—.02
Aug. 30	4	+.09	+.20	+.02	+.06
Jan. 20	2	—.07	—.17	—.10	—.08
Feb. 17	3	+.19	+.07	+.21	+.13
Sept. 19	4	+.12	+.24	+.04	+.14
[*wnn*], [*wvv*]		0.32	0.81	0.20	0.34
10 H. *Camelopardalis.*					
1880		″	″	″	″
Feb. 22	3	—.08	—.18	—.02	—.16
Sept. 18	5	+.08	+.18	—.03	+.05
10 H. *Camelopardalis.* — Cont.					
1881		″	″	″	″
Jan. 5	1	—.16	—.24	—.12	—.17
Oct. 17	2	+.14	+.26	+.10	+.20
[*wnn*], [*wvv*]		0.12	0.45	0.04	0.19
DM. 793.					
1880-81		″	″	″	″
Feb. 8	3	—.07	—.18	—.02	—.08
Feb. 20	4	—.16	—.26	—.07	—.18
Sept. 22	3	+.05	+.15	+.05	+.08
Oct. 17	3	—.11	—.05	—.16	—.06
Feb. 22	4	+.13	+.01	+.11	+.13
Sept. 24	4	+.04	+.16	+.06	+.10
[*wnn*], [*wvv*]		0.23	0.54	0.18	0.28
11 *Camelopardalis.*					
1880-81		″	″	″	″
Feb. 11	3	+.04	—.07	—.02	+.02
Feb. 24	3	—.08	—.17	—.16	—.10
Sept. 23	5	—.07	+.02	—.03	—.06
Oct. 14	4	—.10	—.04	—.02	—.07
Feb. 26	4	+.24	+.12	+.13	+.19
Oct. 8	3	—.05	+.07	+.07	+.03
[*wnn*], [*wvv*]		0.33	0.18	0.16	0.21

t	w	n	n'	v_1	v_2
37 Camelopardalis.					
1880-81		″	″	″	″
Mar. 1	2	—.24	—.33	—.26	—.27
Mar. 18	3½	.00	—.06	+.01	—.03
Nov. 1	2	+.15	+.19	+.15	+.19
Nov. 23	3	—.01	—.01	—.03	+.03
Mar. 9	4	+.17	+.05	+.12	+.10
Oct. 4	1	—.26	—.11	—.20	—.20
[wnn]. [wvv]		0.34	0.33	0.28	0.30
2 Lyncis.					
1880-81		″	″	″	″
Feb. 16	5	—.11	—.21	—.09	—.13
Mar. 8	3	+.12	+.05	+.09	+.10
Sept. 23	5	—.12	—.03	—.13	—.10
Oct. 15	2	—.16	—.10	—.10	—.13
Feb. 25	3	+.10	—.02	+.07	+.05
Mar. 20	4	+.12	.00	—.01	+.03
Oct. 6	2	+.36	+.48	+.44	+.43
[wnn], [wvv]		0.57	0.71	0.56	0.59
14 Lyncis.					
1880-81		″	″	″	″
Feb. 24	2	—.04	—.13	—.07	—.10
Mar. 22	6	+.06	.00	+.02	.00
Oct. 28	3	+.02	+.07	—.05	—.03
Nov. 23	3	+.10	+.10	+.05	+.10
Dec. 22	1	+.16	+.11	+.13	+.15
Mar. 2	2	.00	—.12	—.07	—.10
Mar. 23	6	+.11	—.01	+.01	—.02
Dec. 9	½	—.15	—.08	—.09	—.05
[wnn], [wvv]		0.17	0.12	0.06	0.09
15 Lyncis.					
1880-81		″	″	″	″
Feb. 15	6	+.01	—.06	.00	+.03
Mar. 11	6	—.09	—.16	—.14	—.10
Oct. 9	3	—.28	—.21	—.02	—.24
Nov. 23	3	—.04	—.04	+.15	+.01
Dec. 22	1	—.14	—.20	—.04	—.11
Mar. 3	3	+.11	—.01	+.03	+.06
Mar. 21	7	+.26	+.14	+.15	+.19
Oct. 4	1	— 41	—.29	—.11	—.33
[wnn], [wvv]		1.00	0.58	0.35	0.54
24 Lyncis.					
1880-81		″	″	″	″
Mar. 16	5	—.07	—.14	—.09	—.08
Mar. 28	4½	+.01	—.03	+.01	+.01
Oct. 23	3	—.19	—.13	—.08	—.12
Nov. 23	3	+.06	+.06	+.12	+.11
Mar. 10	7	+.08	—.04	+.01	+.03
Mar. 30	8	+.12	.00	+.01	+.04
Oct. 16	1	—.11	+.01	+.05	.00
Nov. 30	1	—.29	—.20	—.13	—.14
[wnn], [wvv]		0.40	0.22	0.13	0.16
υ Ursae Majoris.					
1879-80		″	″	″	″
Dec. 22	2	—.17	—.29	—.32	—.23
Apr. 12	6	—.06	—.08	—.12	—.07
υ Ursae Majoris. — Cont.					
1880-81-82		″	″	″	″
May 9	5	—.02	+.02	+.07	.00
Nov. 26	2	+.08	+.07	+.13	+.11
Jan. 21	4	+.41	+.31	+.21	+.38
May 10	4	+.13	+.05	+.10	+.03
May 29	5	—.13	—.18	—.06	—.21
Nov. 30	1	—.21	—.12	—.07	—.08
Jan. 15	2	—.03	—.01	—.10	+.06
[wnn], [wvv]		0.96	0.78	0.61	0.97
74 Ursae Majoris.					
1880-81-82		″	″	″	″
May 13	4	—.15	—.11	—.03	—.10
Jan. 22	3	+.23	+.13	+.12	+.21
May 15	7	+.02	—.05	+.02	—.04
Jan. 23	4	—.08	—.08	—.09	.00
[wnn], [wvv]		0.28	0.14	0.08	0.18
75 Ursae Majoris.					
1880-81-82		″	″	″	″
May 14	2	—.16	—.12	+.03	—.03
Jan. 24	2	—.08	—.18	—.10	—.02
May 11	4	—.08	—.16	—.01	—.07
Jan. 19	2	+.01	+.02	+.10	+.18
[wnn], [wvv]		0.09	0.20	0.04	0.09
Radcliffe 3104.					
1880-81-82		″	″	″	″
May 11	2	—.06	—.02	+.04	+.03
Feb. 23	2	—.04	—.16	+.01	—.06
May 22	3	+.01	—.04	—.02	+.01
Jan. 27	2	—.12	—.12	—.01	+.01
[wnn], [wvv]		0.04	0.09	0.00	0.01
ι Draconis.					
1880-81		″	″	″	″
Mar. 6	4	+.08	.00	+.08	—.02
Mar. 27	7	+.02	—.03	—.12	—.07
July 26	5	—.11	+.01	+.04	—.01
Aug. 24	6	—.33	—.21	—.13	—.19
Sept. 24	2	—.32	—.23	—.12	—.17
Mar. 13	4	+.25	+.13	+.05	+.10
Mar. 29	6	+.37	+.25	+.16	+.21
Aug. 10	2	—.05	+.03	+.09	+.03
Sept. 19	5	—.14	+.02	+.13	+.08
[wnn], [wvv]		2.12	0.82	0.54	0.63
θ Draconis.					
1880-81		″	″	″	″
Mar. 14	2½	—.17	—.24	—.31	—.30
Mar. 28	5	+.14	+.10	.00	+.02
July 24	2	+.01	+.13	+.06	+.08
Aug. 15	3	—.15	—.03	—.04	—.05
Aug. 31	3	—.23	—.11	—.08	—.10
Sept. 19	2	—.18	—.08	.00	—.05
Mar. 12	3	+.37	+.25	+.18	+.20
Mar. 29	5	+.27	+.15	+.05	+.07
Aug. 10	2	—.06	+.02	.00	.00
Sept. 19	5	—.14	—.02	+.06	+.01
[wnn], [wvv]		1.34	0.58	0.40	0.42
b Draconis.					
1880-81		″	″	″	″
Mar. 27	2	+.16	+.11	+.02	+.05
Apr. 14	2½	—.04	—.06	—.16	—.15
May 7	4	+.13	+.17	+.07	+.06
Aug. 31	5	—.15	—.04	+.01	—.01
Sept. 13	3	—.25	—.14	—.07	—.09
Oct. 2	3	—.16	—.07	+.02	+.02
Apr. 11	8	+.22	+.11	+.01	+.05
May 13	3	+.20	+.13	+.02	+.02
Sept. 4	4	—.20	—.09	—.04	—.05
Sept. 25	2	—.09	+.03	+.12	+.11
[wnn], [wvv]		1.18	0.42	0.14	0.14
o Draconis.					
1879-80-81		″	″	″	″
Dec. 21	1	+.04	—.08	—.16	+.04
Mar. 23	4	—.02	—.08	—.11	—.14
Apr. 16	3	—.05	—.04	—.05	—.14
May 7	4	+.08	+.12	+.13	.00
Aug. 30	6	—.11	.00	—.01	+.01
Sept. 22	5	—.14	—.04	—.07	+.02
Oct. 22	3	+.08	+.14	+.09	+.25
Apr. 13	5	+.22	+.11	+.10	+.01
May 13	3	—.06	—.13	—.12	—.26
Sept. 6	3	—.14	—.03	—.04	.00
Sept. 21	3	—.07	+.05	+.02	+.11
Oct. 28	1	+.23	+.35	+.29	+.47
[wnn], [wvv]		0.60	0.40	0.38	0.78
Radcliffe 4511.					
1880-81		″	″	″	″
Sept. 18	3	—.12	—.02	+.04	+.01
Oct. 2	3	—.16	—.07	—.09	—.03
Oct. 29	3	+.20	+.24	+.04	+.33
June 11	2	—.08	—.10	—.14	—.27
June 22	4	+.09	+.08	+.08	—.09
[wnn], [wvv]		0.28	0.23	0.09	0.50
Radcliffe 5074.					
1880-81		″	″	″	″
Oct. 31	4	+.01	+.05	+.10	+.12
Nov. 17	1½	—.26	—.26	—.20	—.17
July 14	4	+.07	+.11	—.02	—.06
[wnn]. [wvv]		0.12	0.16	0.10	0.12
B.A.C. 7387.					
1880-81		″	″	″	″
Oct. 31	4	+.21	+.26	+.26	+.33
Nov. 17	2	—.44	—.43	—.42	—.34
July 13	5	+.02	+.05	—.04	—.13
[wnn]. [wvv]		0.57	0.65	0.65	0.75
15 Cephei.					
1880-81		″	″	″	″
Nov. 8	3	—.21	—.18	0.00	—.09
July 25	3	+.19	+.25	0.00	+.09
[wnn]. [wvv]		0.24	0.28	0.00	0.05
24 Stars; total.					
[wnn]. [wvv]		13.27	11.88	6.09	8.87

§8. NYRÉN'S PRIME-VERTICAL OBSERVATIONS OF FOUR STARS, 1875–79.

This is the unpublished series briefly mentioned on p. 65. An examination shows that it constitutes one of the most valuable and decisive that we possess. If we treat it in what has been heretofore the customary manner, when the existence and true law of the latitude-variation was unknown, the stars give indeed extremely discordant values of the aberration-constant, as follows:

δ Cassiopeae,	$\alpha =$	$1^h\ 18^m$	$20''.653$
υ Ursae Majoris,		$9\ \ 42$	20.669
ι Draconis,		$15\ \ 22$	20.236
o Draconis,		$18\ \ 49$	20.113

These values betray, in an exaggerated form, systematic discordances like those which NYRÉN subsequently found in the 21 stars observed in 1879–82, discussed in his published memoir on the aberration. The reason will be obvious by referring to the left-hand page of the charts in no. 277. It will there be seen that the amplitude of the latitude-variations between 1875 and 1879 (Julian dates 240 6100–7400) was very large, while from 1879 to 1882 (240 7700–8500) it was small. The investigation which I now proceed to give results in a formula for the latitude-variation agreeing well with that derived from the Vertical Circle 1863–75 (eq. (41) and (42)), while the differences above shown, between the aberrations from the four stars, almost completely disappear.

The observations were reduced to 1881.0, and mean values of n formed, as given in Table VII below, with the declinations and proper motions assumed for the same stars in the later observations, given in Table VI. Forming equations of condition according to (35), computing the coefficients of (25) with $\theta = 0°.835$, $T'_0 = 240\,7091$, we get the following normal equations from all the observations of these four stars from 1875 to 1882. The two values of n inclosed in brackets in Table VII were rejected as anomalous.

δ Cassiopeae.

$$\begin{array}{rrrrrcr}
+102.75X & +14.18\,Y & -16.43Z & +\ 3.04y & +\ 8.61z & = & -\ 9''.12\\
+\ 14.18 & +71.53 & -26.09 & -\ 3.29 & -\ 8.92 & = & +11.24\\
-\ 16.43 & -26.09 & +31.11 & +\ 6.81 & -\ 8.69 & = & -\ 7.74\\
+\ \ 3.04 & -\ 3.29 & +\ 6.81 & +46.59 & -10.18 & = & -\ 2.45\\
+\ \ 8.61 & -\ 8.92 & -\ 8.69 & -10.18 & +56.24 & = & -10.70
\end{array}$$

υ Ursae Majoris.

$$\begin{array}{rrrrrcr}
+\ 67.00X & +16.95\,Y & +23.51Z & +\ 4.13y & -\ 3.57z & = & -\ 2''.80\\
+\ 16.95 & +45.15 & +19.62 & -\ 1.27 & -\ 9.20 & = & -\ 6.75\\
+\ 23.51 & +19.62 & +21.93 & +\ 0.41 & -\ 7.82 & = & -\ 3.00\\
+\ \ 4.13 & -\ 1.27 & +\ 0.41 & +37.82 & +\ 0.44 & = & -\ 2.91\\
-\ \ 3.57 & -\ 9.20 & -\ 7.82 & +\ 0.44 & +29.21 & = & -\ 2.81
\end{array}$$

ι Draconis.

$$\begin{array}{rrrrrcr}
+105.50X & +34.07\,Y & -\ 9.44Z & -12.92y & -\ 9.74z & = & -\ 1''.15\\
+\ 31.07 & +30.52 & -25.72 & -\ 4.07 & -11.05 & = & +\ 2.72\\
-\ \ 9.44 & -25.72 & +75.01 & -\ 1.34 & -\ 1.65 & = & -\ 0.35\\
-\ 12.92 & -\ 4.07 & -\ 1.34 & +46.01 & +\ 3.05 & = & -\ 2.90\\
-\ \ 9.74 & -11.05 & -\ 1.65 & +\ 3.05 & +59.49 & = & -14.99
\end{array}$$

o Draconis.

$$\begin{array}{rrrrrcr}
+101.50X & +20.56\,Y & -19.21Z & -\ 4.59y & +\ 3.60z & = & -\ 3''.64\\
+\ 20.56 & +25.41 & +18.33 & +\ 3.07 & +\ 1.20 & = & -\ 3.43\\
-\ 19.21 & +18.33 & +76.17 & +\ 3.87 & -\ 4.65 & = & -\ 8.61\\
-\ \ 4.59 & +\ 3.07 & +\ 3.87 & +44.11 & +\ 6.41 & = & -\ 5.69\\
+\ \ 3.60 & +\ 1.20 & -\ 4.65 & +\ 6.41 & +57.29 & = & -13.06
\end{array}$$

Eliminating X, Y, and Z, and adding the elimination-equations, we have

$$\begin{array}{rrcr}
+169.371\,y & -\ \ 0.007\,z & = & -11''.574\\
-\ \ 0.007 & +183.370 & = & -41.413
\end{array}$$

whence, $y = -0''.0683$. $z = -0''.2258$

which, by (30) and (25) give $T'_0 = 240\,7111$, $r_1 = 0''.236$.

Substituting y and z in the normal equations for the four stars, and solving, we have,

	X	Y	w_1	Z	w_2
δ Cassiopeae,	$-0''.126$	$+0''.0262$	49.6	$-0''.3416$	20.3
υ Ursae Majoris,	$+\ .026$	$-\ .1653$	27.2	$-\ .0961$	9.1
ι Draconis,	$-\ .069$	$+\ .0827$	12.6	$+\ .0089$	47.8
o Draconis,	-0.070	$+0.0518$	14.4	-0.1537	49.3

By (27), (37) and (38), we get,

		w_0
δ Cassiop.	$+0.813\eta - 0.063\zeta + 0.665u = +0''.043$	74.0
υ Urs. Maj.	$-\ .712\ \ -\ .245\ \ +\ .567\ \ = +\ .141$	39.6
ι Draconis,	$-\ .547\ \ +\ .812\ \ +\ .958\ \ = -\ .038$	26.6
o Draconis,	$+0.184\ \ +0.974\ \ +0.983\ \ = -0.140$	46.3

which give the normal equations,

$$\begin{array}{rrrcr}
+78.518\,\eta & -\ 0.406\,\zeta & +\ 18.478\,u & = & -2''.015\\
-\ 0.406 & +64.140 & +\ 56.392 & = & -8.730\\
+18.478 & +56.392 & +114.565 & = & -2.033
\end{array}$$

whence $\eta = -0''.0507$, $\zeta = -0''.2257$, $u = +0''.1015$

The aberration consequently is $20''.547$. This result, however, is not entirely independent of that in §7, and I think it better to make it so by deriving it from the observations of 1875–79 alone. Accordingly, substituting the above values of y, z, η and ζ, in the original equations for this portion of the series, and solving according to (40), we get,

	X	Y	w_1	Z	w_2
δ Cassiopeae,	$-0''.149$	$+0''.0751$	34.0	$-0''.1968$	10.3
υ Ursae Majoris,	$+\ .080$	$-\ .0899$	9.7	$+\ .0196$	4.0
ι Draconis,	$-\ .089$	$+\ .1524$	8.4	$+\ .2318$	21.3
o Draconis,	-0.140	$+0.1980$	8.5	$+0.0159$	23.9

Introducing these values of Y and Z, and their weights, in (28), putting $\delta\eta$ and $\delta\zeta$ for η and ζ, and ignoring π, we get the normal equations,

$$\begin{array}{rrcr}
+60.600\,\delta\eta & +17.705\,u & = & +4''.637\\
+17.705 & +30.193 & = & +2.306
\end{array}$$

$$\begin{array}{rrcr}
+59.500\,\delta\zeta & +38.946\,u & = & +3''.375\\
+38.916 & +36.999 & = & +4.493
\end{array}$$

whence the most probable value of $u = +0''.0886$.

Consequently the aberration from the observations of 1875–79 alone is

$20''.534$

which I adopt as the definitive value from this series. We also have $\delta\eta = +0''.0506$, $\delta\zeta = -0''.0012$; which, added to the above η and ζ, give, by (30), $G' = 360°.0$ and $r_2 = 0''.227$. Consequently the expression for the latitude-variation is,

$$\varphi - \varphi_0 = -0''.236\cos(t - 1878\text{ May }6) \times 0°.835 \qquad (46)$$
$$-0''.227\cos(\odot - 360°.0)$$

It is of interest to compare the values of the aberration for the separate stars after the elimination of the latitude-variation, with those which result when it is ignored. The former are given in column I below (determined by (34)), and the latter in column II.

	I	II
	″	″
δ Cassiopeae,	20.555	20.653
υ Ursae Majoris,	20.549	20.669
ι Draconis,	20.555	20.236
o Draconis.	20.498	20.113

The beautiful agreement in I, and the intolerable discordance in II, afford most convincing evidence, if any were now needed, of the reality of the law of the latitude-variation.

An indeterminate solution has also been made for the observations of 1875–1879 alone, in the same manner as for Struve's observations in §6. This may be useful in showing how far the aberration here deduced is independent of the particular values attributed to the constants of the latitude-variation. Without giving the details of the solution I will simply present the resulting equations.

$$\begin{aligned} \eta &= +0''.009 \;+0.004\,y \;+0.263\,z \\ \zeta &= -0\;.232 \;+0.033 \;\;\; -0.037 \\ \text{Aberration} &= \;\;20\;.551 \;-0.037 \;\;\; +0.033 \end{aligned}$$

It only remains to say, that the values of v in Table VII are the residuals which come from the substitution of the values of X, Y and Z, given near the end of p. 69, in the equations from which they were derived.

Table VII. Nyrén's Prime-Vertical Observations, 1875–79.

t	*w*	*n*	*v*
δ Cassiopeae.			
		″	″
75 July 7	1¼	+.10	—.08
18	4	+.17	—.06
25	3	+.30	+.04
Dec. 3	1½	—.46	—.19
11	3	—.44	—.11
28	4	—.56	—.09
76 Feb. 15	1	—.33	+.36
June 3	3	—.33	—.25
11	1¼	—.15	—.15
20	1	—.03	—.11
29	3	+.17	+.01
July 24	2	+.38	+.05
Dec. 10	4	—.02	+.17
77 Feb. 14	4	—.70	+.04
June 12	¼	—.43	—.14
July 7	2	+.22	+.16
24	4	+.39	+.17
Dec. 9	1½	—.03	—.06
78 Jan. 24	2	—.44	—.02
Feb. 14	1	—.57	+.04
27	2¼	—.68	.00
June 21	4	—.28	+.02
July 2	1¼	+.02	+.22
16	1½	+.25	+.32
27	2	—.18	—.22
Aug. 2	3	—.05	—.13
[*wnn*], [*wvv*]		8.33	1.16
υ Ursae Majoris.			
		″	″
75 Oct. 21	2	+.86	+.76
Dec. 1	3	—.35	—.41
76 Apr. 22	4	+.03	+.16
May 11	3	—.02	+.04
June 2	4	—.10	—.14
Dec. 1	2	+.45	+.23
13	2	+.05	—.10
77 May 21	2	—.13	+.10
June 3	2	—.28	—.12
27	1	—.03	+.02
78 Apr. 29	2	—.17	+.23
May 11	3	—.36	+.03
15	3	—.43	—.05
June 19	2	—.62	—.36
Nov. 8	1	+.07	—.46
29	1	(+.80)	–
Dec. 28	3	(+.77)	–
[*wnn*], [*wvv*]		4.26	2.63
ι Draconis.			
		″	″
75 July 18	4	+.15	—.01
22	3	+.38	+.23
25	3	—.01	—.16
Aug. 11	2	+.11	+.04
76 Jan. 11	1	—.02	+.39
Mar. 14	1	+.08	+.27
ι Draconis. — Cont.			
		″	″
76 Apr. 1	2	—.14	—.04
July 29	2	+.14	—.09
Aug. 8	4	+.25	+.04
13	3	+.28	+.08
26	2	—.04	—.21
Sept. 25	1	+.05	—.01
77 Feb. 13	2	—.42	—.04
Mar. 11	3	—.43	—.10
22	2	—.45	—.14
July 20	3	+.16	+.06
26	3	+.30	+.18
Oct. 4	2	—.03	—.15
78 Feb. 13	1½	+.23	+.46
22	2	—.02	+.22
Mar. 13	2	—.74	—.48
25	3	—.30	—.04
Aug. 2	4	—.08	+.01
9	3	.00	+.07
24	3	—.11	—.06
Sept. 5	2	—.17	—.15
16	1	—.19	—.18
[*wnn*], [*wvv*]		4.38	1.78
o Draconis.			
		″	″
75 Sept. 29	3	+.08	+.10
Oct. 16	2	+.05	+.18
o Draconis. — Cont.			
		″	″
75 Nov. 8	2	—.37	—.08
23	1	—.36	+.02
76 Apr. 16	3	+.04	+.28
May 10	2	+.14	+.03
Aug. 24	2	+.26	—.08
Sept. 1	5	+.43	+.12
12	2	+.45	+.17
28	1	+.22	+.02
77 Apr. 4	1½	—.77	—.26
19	2	—.51	—.09
May 16	2	—.32	—.08
23	3	—.43	—.24
Oct. 4	2	+.16	—.11
19	2	+.08	—.13
Nov. 5	2	—.08	—.20
78 Mar. 24	1	—.53	.00
Apr. 8	2	—.16	+.34
23	2	—.41	+.05
May 5	3	—.68	—.26
14	3	—.23	+.15
Sept. 6	4	+.06	—.10
14	3	+.18	+.01
30	2	+.10	—.07
Oct. 19	3	+.20	+.04
[*wnn*], [*wvv*]		6.69	1.50

OBSERVATIONS OF SOME SUSPECTED VARIABLE STARS,

By EDWIN F. SAWYER.

In vol. VIII, no. 184, of the *A.J.*, I published the observations of a number of stars whose constancy of light had been suspected with greater or less reason, by many authorities, but chiefly selected from the large number of such cases published in the *Uranometria Argentina*. The following observations form a continuation of this list. The arrangement of the stars is in the order of right-ascension, the places being for 1875. The observations represent the results derived from the sequences, together with other and separate comparisons with two or more neighboring stars; the magnitudes given being the average deduced values from Dr. Gould's work, and my recently published revision of the same.*

Although the evidence in most of the cases given is decidedly in favor of the constancy of light, yet a few stars specially mentioned need further attention, which will be given as the opportunity offers.

With the exception of those made in the years 1892 and 1893, the observations will be found in detail in my Catalogue.

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* Now being distributed.

No.	U.A. No.	1875.0		No. Obs.	Included Dates		Range in Mag.		Range at Cordoba	
		α	δ							
		h m s	° '							
1	72 *Ceti*	0 37 53	—11 17.3	6	1882 to	1892	4.9 to	5.1	4.9 to	5.3
2	108 *Piscium*	1 1 50	+ 9 14.4	6	"	"	6.7	6.95	. . .	
3	110 *Piscium*	2 23	+ 9 3.9	6	"	"	7.0	7.1	. . .	
4	112 *Piscium*	4 56	+ 9 37.6	6	"	"	6.4	6.6	. . .	
5	118 *Ceti*	8 6	— 8 35.7	4	1884	1892	5.1	5.2	5.3	5.7
6	132 *Ceti*	16 11	— 1 6.2	4	1882	1892	6.8	6.9	6.6	7.3
7	124 *Sculptoris*	33 30	—29 39.5	6	1884	1892	7.0	7.2	. . .	
8	133 *Piscium*	47 46	+ 8 9.9	4	1882	1889	6.85	6.9	. . .	
9	192 *Ceti*	51 38	— 2 40.2	6	1882	1892	6.25	6.4	. . .	
10	135 *Piscium*	53 39	+ 2 30.1	6	"	"	5.8	6.15	6.0	6.4
11	15 *Fornacis*	58 53	—29 53.8	3	1884	1886	. . .		4.9	5.7
12	224 *Ceti*	2 6 24	— 2 58.7	7	1882	1892	5.4	5.6	5.7	5.9
13	100 *Leporis*	6 5 36	—27 7.6	6	1882	1893	6.2	6.35	5.9	6.4
14	80 *Canis Majoris*	45 6	—27 11.4	9	"	"	7.1	7.3	. . .	
15	108 *Puppis*	7 28 42	—22 1.6	6	"	"	5.0	5.3	4.5	4.9
16	111, 12 *Puppis*	29 2	—23 12.2	7	"	"	5.6	5.8	5.6	6.0
17	308 *Puppis*	8 20 48	—12 7.5	6	1884	1893	6.0	6.3	5½	6
18	6 *Pyxidis*	24 12	—26 55.0	6	"	"	6.9	7.05	6.9	7.7
19	20 *Pyxidis*	34 31	—29 7.0	6	"	"	5.4	5.65	5½	5¾
20	70 *Hydrae*	45 26	— 6 42.5	6	"	"	5.8	5.95	5.7	6.3
21	47 *Pyxidis*	57 41	—25 0.6	6	"	"	6.8	6.95	6.8	7.0
22	141 *Hydrae*	9 21 35	—21 47.7	7	"	"	5.3	5.4	. . .	
23	170 *Hydrae*	33 28	— 0 34.5	7	"	"	3.9	4.3	3.7	4.3
24	257 *Hydrae*	10 47 23	—19 27.8	6	"	"	5.4	5.65	5.2	5.7
25	272 *Hydrae*	11 3 53	—31 41.3	7	"	"	5.85	6.1	5.6	6.1
26	139 *Virginis*	13 16 20	—17 4.8	5	1882	1888	5.65	5.8	5.2	5.9
27	148 *Virginis*	20 47	—15 19.5	4	"	"	5.0	5.1	4.8	5.4
28	238 *Virginis*	14 13 6	— 1 41.2	5	"	"	5.7	5.8	5.1	5.6
29	241 *Virginis*	15 32	— 1 24.9	5	"	"	6.8	7.0	6.8	7.2
30	22 *Scorpii*	16 0 6	—13 44.0	5	"	"	6.5	6.7	6.7	7.0
31	48 *Scorpii*	8 48	—14 32.0	4	"	"	6.25	6.45	6.1	6.7
32	15 *Ophiuchi*	19 47	—18 10.2	12	1882	1892	4.6	5.0	4.3	4.7
33	70 *Ophiuchi*	54 28	— 4 2.0	50	"	"	5.4	5.5	5.1	5.9
34	141 *Ophiuchi*	17 20 0	— 4 58.4	11	"	"	4.65	4.9	4.5	5.1
35	149 *Ophiuchi*	23 47	—23 51.8	5	"	"	5.1	5.3	4.8	5.6
36	32 *Sagittarii*	18 0 33	—17 10.1	11	"	"	5.8	6.0	. . .	
37	50 *Sagittarii*	9 54	—17 24.9	15	"	"	6.3	6.65	. . .	
38	56 *Sagittarii*	13 50	—24 58.1	10	"	"	6.7	7.0	6	7½
39	73 *Sagittarii*	21 39	—25 20.0	8	"	"	6.7	6.9	. . .	
40	14 *Scuti*	28 24	— 8 19.8	13	"	"	3.55	4.1	. . .	
41	104 *Sagittarii*	42 15	—20 27.9	9	"	"	5.5	5.75	5.4	5.9
42	142 *Sagittarii*	59 49	—18 55.7	9	"	"	6.5	6.8	6.3	7.0
43	147 *Sagittarii*	19 2 20	—21 13.2	7	"	"	2.9	3.1	2.7	3.2
44	182 *Sagittarii*	17 56	—24 12.3	14	"	"	5.6	6.1	½ mag.	
45	53 *Aquilae*	25 54	+ 2 38.8	11	1888	1892	6.7	6.8	6.3	7.2
46	135 *Aquilae*	20 18 15	+ 0 40.0	13	1882	1892	6.1	6.5	5.8	6.4
47	146 *Aquilae*	31 53	— 1 32.4	8	1884	1892	4.5	4.8	. . .	
48	13 *Aquarii*	45 32	— 5 58.5	10	1882	1892	5.55	5.75	5.1	5.8
49	24 *Aquarii*	50 9	—10 10.5	10	"	"	5.75	6.05	5.8	6.1
50	78 *Capricorni*	21 2 24	—21 3.2	9	"	"	6.5	6.65	6.3	6.8
51	49 *Aquarii*	4 2	— 9 51.6	10	"	"	6.5	6.6	6.3	6.6
52	66 *Microscopii*	14 24	—29 41.7	10	1884	1892	6.6	6.85	6.5	6.9
53	176 *Aquarii*	22 36 52	—19 29.0	11	1882	1892	4.9	5.2	4.8	5.6
54	239 *Aquarii*	23 23 4	— 5 12.7	11	1884	1892	6.2	6.35	. . .	
55	31 *Piscium*	23 6	— 1 43.4	11	1882	1892	6.5	6.8	. . .	
56	243 *Aquarii*	25 57	—11 41.3	10	1884	1892	6.8	6.9	6.7	7.1
57	8 *Ceti*	58 6	—11 12.2	8	1882	1892	5.15 to	5.35	4.9 to	5.9

The blank spaces in columns 6 and 7 indicate either no range, or, that the extent of same is not given in the notes accompanying the *U.A. Catalogue*.

Colored stars: Nos. 13, 17, 19, 26, 33, 37, 38, 44 and 45.

Difficult stars to observe, owing to low altitude, brightness or other cause: Nos. 7, 10, 11, 14, 23, 32, 34, 38, 39, 40, 41, 43, 47, 52 and 53.

Considered variable at Cordoba: Nos. 7, 10, 11, 13, 14, 17, 18, 19.

20, 24, 25, 26, 27, 28, 31, 32, 33, 35, 38, 40, 41, 42, 44, 45, 46, 48, 49 and 57.

Considered variable by other authorities: Nos. 8, 9, 12, 21, 22, 29, 39, 54, 55 and 56.

Stars needing further watching: Nos. 10, 11, 15, 38, 44, 45, 46 and 49.

Brighton, 1893 *March* 28.

FILAR-MICROMETER OBSERVATIONS OF COMET *f* 1892 (*HOLMES*),

MADE WITH THE 15½-INCH EQUATORIAL OF THE WASHBURN OBSERVATORY, MADISON, WIS.,

By A. S. FLINT, Assistant Astronomer.

[Communicated by George C. Comstock, Director.]

1893 Madison M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			m s	′ ″	h m s	° ′ ″		
Jan. 26 9 54 20	1	6 , 6	—0 23.16	—0 52.0	. . .	. . .	9.691	0.585
Feb. 3 9 16 5	2	6 , 6	+1 41.06	+1 35.8	. . .	. . .	9.675	0.578
7 8 37 35	3	10 . 7	+0 29.32	—3 50.5	. . .	. . .	9.648	0.493
11 8 39 11	4	4 , 4	—0 43.93	—1 0.6	. . .	. . .	9.662	0.514
10 17 15	4	4 , 8	—0 37.09	—0 59.2	. . .	. . .	9.716	0.687
16 8 56 20	5	7 . 10	+0 8.50	+7 11.1	2 7 48.17	+34 14 32.6	9.688	0.563

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 36 9.4	—0.91	+33 43.8	+8.2	DM. 33°282
2	1 45 46.0	—0.96	+33 49.5	+8.1	Anonymous
3	1 53 5.2	—1.00	+34 2.1	+8.0	DM. 33°332
4	2 0 31.3	—1.00	+34 4.9	+8.0	DM. 33°363
5	2 7 41.38	—1.05	+34 7 17.1	+7.9	⅓(W.B. II, 110+2 Leiden V 58. no. 81)

The above observations were made as opportunity offered during the progress of meridian-work.

Jan. 26. Bright moonlight and haze. Comet has no definite condensation.

Feb. 3. Comet growing fainter and more undefined during observations, on account of rising moon.

Feb. 7. Fixed thread on star, movable thread on comet. Latter loosened by hitching; visibly just after the series of observations, possibly also before. Result of observation involves last observed coincidence of fixed thread, Dec. 3. Injured thread removed.

Feb. 11. In the first observation pointings were made on a faint star in the midst of the comet which appeared as an undefined cloud. In the second observation, and in that of Feb. 16, the micrometer-thread was made to approach the comet from either side alternately while pointing in declination.

Feb. 16. Comet a mere ghost. Obliged to set fixed thread on comet.

Feb. 18. Comet too indefinite for observation. The advancing edge of the mass of light is pronounced, and the following light more than fills the whole field. diameter 11′.6. In the finder the light extends north and east about 6′.

Feb. 25. Comet invisible. Bright moonlight.

RETURN OF PERIODIC COMET 1886 VII.

The periodic comet 1886 VII, discovered by Finlay at the Cape of Good Hope, 1886 Sept. 26, has been again found by him, on May 17, at its return; and observed as follows:

1893 May 18.6262 Greenwich M.T. $\alpha = 23^h\ 42^m\ 1^s.2$, $\delta = -5°\ 1'\ 50''$.

He describes it as circular, 1′ in diameter, very diffuse, without tail, and 11^M or fainter.

CORRIGENDUM.

In the title of No. 296, *for* Vol. XIII, no. 7, *put* Vol. XIII, no. 8.

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Rediscovery of Periodic Comet 1886 VII.
Corrigendum.

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THE

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CHRONOLOGY AND ECLIPSES.

By JOHN N. STOCKWELL.

In various numbers of this Journal, commencing with no. 240, I have contributed several articles on the subject of chronology, giving, as far as possible the testimony bearing on the question, which is afforded by ancient eclipses. This evidence has perhaps not been wholly conclusive, because the descriptions of ancient eclipses by historians have not been given with sufficient fullness to enable us to identify, with certainty, more than *one* ancient eclipse. In no. 280 of this Journal I have given a *resumé* of the evidence previously discovered; from which the conclusion that the origin of the Olympiads should be placed one year earlier in chronology is rendered highly probable. It was then my intention to discontinue the discussion of the subject, for a time at least; but circumstances over which I had no control, disarranged my plans, and I have continued that line of investigation, amidst numerous interruptions, ever since. The result of this additional study has been the discovery of the records of two ancient eclipses, which can be identified with certainty; and which are so interwoven with the political and general history of those times, that I think there can no longer be any doubt in regard to the correctness of my conclusions.

The records of these two eclipses are given by Theophanes, who informs us that in the month of *Daesius*, in the *tenth* year of Constantius, within the *third* hour of the day, an eclipse of the sun took place at Constantinople, so great that stars appeared. This eclipse is also mentioned by Cedrenus, Eusebius and Hieronymus, who all refer it to the tenth year of Constantius; and it is the first eclipse of antiquity in which the hour of its occurrence is given with any attempt at precision by the general historian. It took place A.D. 346 June 6; and at $7^h\ 2^m$ in the morning, according to my computations, the apparent distance between the centers of the sun and moon was only 41″.6; whereas the difference of their semidiameters was 45″.8. The eclipse was therefore total at Constantinople, the totality lasting very nearly one minute. Moreover, the sun rose at $4^h\ 30^m$; and the eclipse was therefore greatest at $2^h\ 32^m$ after sunrise, which agrees exactly with the statement of Theophanes.

The description of the second eclipse is still more precise; for Theophanes states that at the *second* hour of the Lord's day, in the course of the *eleventh* year of Constantius, a large partial eclipse of the sun took place. In this eclipse we have, not only the hour of the day, but also the day of the week given; and these conditions are sufficient to fix with mathematical certainty the date of its occurrence. This eclipse is also mentioned by Cedrenus, Hieronymus, and by Cassiodorus; who all state that it occurred in the *twelfth* year of Constantius, instead of the *eleventh* year as stated by Theophanes. Now the only eclipse, visible at Constantinople, which took place on a Sunday during the reign of Constantius, was that of A.D. 348 October 9. According to my computations, the time of greatest eclipse at Constantinople was at $8^h\ 24^m$ in the morning, at which time the apparent distance between the centers of the sun and moon was 403″.4, and the magnitude of the eclipse was then equal to 9.7 digits on the sun's northern limb. At that date the mean time of sunrise at Constantinople was at $6^h\ 12^m$; and therefore the eclipse took place $2^h\ 12^m$ after sunrise, agreeing exactly with the description by Theophanes.

This second eclipse happened about two years and three months after the first; so that if the first happened in the tenth year of Constantius, the second must have occurred in the twelfth year, agreeably to the statements of the historians. They also show that the chronology of the reign of Constantius is correctly determined, since the historical and astronomical records agree. But Hieronymus, who is better known as "Saint Jerome," after stating that this second eclipse took place in the twelfth year of Constantius, makes the additional interesting and important statement that it also occurred in the *first year* of the *two hundred and eighty-second Olympiad*. The year A.D. 348, was therefore the first of an Olympiad: it was also a leap-year. It thus follows that the Olympic games were celebrated in the bissextile or leap-years of the Julian calendar. Moreover, if the year A.D. 348 was the first year of the two hundred and eighty-second Olympiad, the first Olympiad must have been celebrated 1124 years before A.D. 348. But 348 —1124 = —776 = B.C. 777: and this agrees with the date of the first Olympiad as determined by the eclipse of Phlegon, which took place 319 years before. These two eclipses are the only ones of antiquity which are referred by the historians directly to the Olympic era; the date of which they serve to determine with certainty, and are therefore of priceless value; for Hieronymus was a contemporary of Constantius, and his testimony is personal and explicit. But the direct testimony of the eclipses of Phlegon and Theophanes, is circumstantially corroborated by the numerous other eclipses which have already been discussed in previous numbers of this Journal; and it seems to me that we may now regard the year B.C. 777 as the first of the Olympic era, as having been satisfactorily established on a mathematical and astronomical basis.

But these eclipses of A.D. 346 and 348 have other than chronological importance; for they also serve as a valuable test of the correctness of the theory of the moon's motion on which the calculation of the moon's place in the heavens is determined. It will be remembered that I have employed a value of the secular variation of the motion of the moon's perigee which is fundamentally different from that of other astronomers; and this difference of secular equations is sufficient to change the calculated time of an eclipse by nearly three-quarters of an hour, if it occurred fifteen hundred years ago. But we have seen that the calculated times and magnitudes of these eclipses agree perfectly with the observed times as recorded by the historians; and this agreement is very strong presumptive evidence that the theory on which the calculations are based must be essentially correct.

Cleveland, Ohio, 1893 *May* 10.

THE SUN'S MOTION THROUGH SPACE.

By A. D. RISTEEN.

Since Herschel's first determination of the direction of the sun's motion, astronomers have given the subject considerable attention, and numerous other and better determinations have been made. So far as I am aware, all of these have been based upon the same general principle, and the position of the solar apex has been deduced always by analyzing the proper motions of the stars. It has seemed to me that it would be interesting to examine the motions of the stars in the line of sight also, and to compare the results obtained in this way with those yielded by the older and more conventional method. The one method ought at least to furnish a valuable check upon the other.

The fundamental assumptions upon which the proposed method rests are, (1) that the stars used in the computation have no tendency to drift in any particular direction; (2) that their absolute velocities do not depend upon their apparent positions in the heavens; and (3) that these absolute velocities are not functions of their own directions. The second and third of these assumptions are almost axiomatic, and it is worthy of note that the first one underlies the usual method of investigation, as well as the one here proposed. Another assumption is involved to a certain extent; namely, that the absolute velocity of a star is not a function of the star's apparent brightness. I have not included this in the foregoing list, because it does not appear to affect the concluded *direction* of the sun's motion; but since spectroscopic measures have as yet been obtained only from the brighter stars, it will be apparent that if bright stars move through space faster than faint ones, the *velocity* of the sun's motion, as deduced from measures now available, will be too great; and conversely. It is important to notice that all of the assumptions mentioned above are of a negative character; and it will be particularly observed that we make no assumption about possible relations between the brightness and the distance of stars, nor do we assume anything about the relation of distance to apparent motion. I feel that these two facts are powerful arguments in favor of the spectroscopic method.

The form of the condition equation is easily deduced. Let v be a star's observed velocity of recession (corrected, of course, for the earth's motion), V the sun's velocity through space, and φ the arc of the heavens between the star and the solar apex. Then we have, as the required condition equation,

$$V\cos\varphi + v = 0 \qquad (1)$$

Since the position of the apex is supposed to be unknown, we cannot compute φ, but must express it in terms of the known right-ascension and declination of the star (α and δ), and the unknown right-ascension and declination of the apex (α_0 and δ_0). We have

$$\begin{aligned}\cos\varphi = \sin\delta_0\cdot\sin\delta &+ \cos\delta_0\cos\alpha_0\cdot\cos\delta\cos\alpha \\ &+ \cos\delta_0\sin\alpha_0\cdot\cos\delta\sin\alpha\end{aligned}$$

and by substituting in (1) we obtain

$$(2)\quad \sin\delta\cdot K_1 + \cos\delta\cos\alpha\cdot K_2 + \cos\delta\sin\alpha\cdot K_3 + v = 0$$

where

$K_1 = V\sin\delta_0$, $K_2 = V\cos\delta_0\cos\alpha_0$, and $K_3 = V\cos\delta_0\sin\alpha_0$,

so that

$$\left.\begin{aligned} V^2 &= K_1^2 + K_2^2 + K_3^2 \\ \sin\delta_0 &= \frac{K_1}{V}, \quad \text{and} \quad \tan\alpha_0 = \frac{K_3}{K_2} \end{aligned}\right\} (3)$$

Dr. Vogel's recently published measures* of the velocities of recession of the brighter stars visible at Potsdam enable us to construct forty-two equations of the form (2). Dr. Vogel gives results for fifty-one stars, but I have excluded nine for various reasons; thus *α Canis majoris* and *α Canis minoris* are known to be subject to irregularities of motion that are not yet perfectly understood. The stars β, γ, δ, ε, and ζ *Ursae majoris* are known to be drifting together, so only one of them has been included. The other omissions will be readily understood by referring to Dr. Vogel's memoir. Following are the forty-two observation-equations obtained as described above. The numbers under K_1, K_2, and K_3. are coefficients of those quantities. Thus the first equation, for instance, is

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* *Publicationen des astrophysikalischen Observatoriums zu Potsdam.* VII Band. I Theil: 1892.

$$0.477\,K_1 \;+0.879\,K_2 \;+0.011\,K_3 \;+0.6 = 0$$

The sixth and seventh columns respectively contain the calculated velocity of the sun in the direction of the star, and the residual motion that we must suppose is proper to the star itself.

Star	K_1	K_2	K_3	v	Sun	Star
α *Andromedae*	+0.477	+0.879	+0.011	+0.6	—0.4	+0.2
β *Cassiopeae*	.853	.522	.008	+0.7	+0.7	+1.4
α *Cassiopeae*	.829	.555	.074	—2.1	0.6	—1.5
γ *Cassiopeae*	.867	.486	.108	—0.5	+0.7	+0.2
β *Andromedae*	0.574	.788	.224	+1.5	—0.3	+1.2
α *Ursae min.*	1.000	.021	.007	—3.5	+1.6	—1.9
γ *Andromedae*	0.667	.650	.364	1.7	—0.1	1.8
α *Arietis*	.390	.797	.465	2.0	0.9	2.9
β *Persei*	.650	.535	.540	0.2	—0.2	0.4
α *Persei*	.760	.425	.491	—1.4	+0.2	—1.2
α *Tauri*	.280	.369	.886	+6.5	—0.9	+5.6
α *Aurigae*	+ .718	.155	.679	3.3	+0.3	3.6
β *Orionis*	— .145	.217	.965	2.2	—1.5	0.7
γ *Orionis*	+ .109	.175	.978	1.2	1.1	0.1
β *Tauri*	+ .477	.155	.865	1.1	0.3	+0.8
δ *Orionis*	— .007	.146	.989	0.1	1.2	—1.1
ε *Orionis*	— .022	.128	.992	3.6	1.2	+2.4
ζ *Orionis*	— .035	.107	.993	2.0	1.2	0.8
α *Orionis*	+ .129	.017	.991	+2.3	—0.9	+1.4
β *Aurigae*	.706	+ .026	.707	—3.8	+0.4	—3.4
γ *Geminorum*	.284	— .131	.950	—2.2	—0.3	—2.5
β *Geminorum*	.474	.367	.801	+0.2	+0.4	+0.6
α *Leonis*	.216	.851	.478	—1.2	1.0	—0.2
γ *Leonis*	.349	.839	.418	5.2	1.3	3.9
β *Ursae maj.*	.838	.524	.152	4.0	1.9	—2.1
α *Ursae maj.*	.886	.446	.126	1.6	1.9	+0.3
δ *Leonis*	.360	.910	.209	1.9	1.6	—0.3
β *Leonis*	+ .262	.962	+ .069	1.6	1.6	0.0
α *Virginis*	— .184	.924	— .334	2.0	1.2	0.8
η *Ursae maj.*	+ .764	.580	.281	3.5	2.3	—1.2
α *Bootis*	.338	.792	.508	1.0	2.1	+1.1
ε *Bootis*	.462	.679	.571	—2.2	2.3	0.1
β *Ursae min.*	.964	.195	.181	+1.9	2.1	4.0
α *Coronae Bor.*	.455	.542	.707	+4.3	2.2	+6.5
β *Herculis*	— .370	— .373	— .851	—4.8	+2.0	—2.8
α *Ophiuchi*	.219	— .128	.967	+2.6	—1.5	+4.1
α *Lyrae*	.625	+ .113	.772	—2.1	1.7	—0.4
α *Aquilae*	—0.149	+0.439	—0.886	—5.0	—0.6	—4.4
γ *Cygni*	—0.641	+0.436	—0.631	—0.9	—1.1	+0.2
α *Cygni*	.706	.450	.547	—1.1	+1.2	0.1
ε *Pegasi*	— .163	.805	.570	+1.1	—0.2	+0.9
α *Pegasi*	+0.252	+0.934	—0.254	+0.2	—0.6	—0.4

In forming the normal equations I have not assigned weights, for although some of the measures are undoubtedly better than others, in my opinion it would be wrong to give them greater weight. Such a procedure would give to the absolute motion of well-observed stars an undue influence over the concluded motion of the sun. It is probable that the radial velocities which are proper to the stars examined, are distributed in accordance with the Gaussian law. It is not probable that they are so distributed, if they are first multiplied by factors expressing the worth of our measures.

The normal equations are

$$\begin{aligned}12.53\,K_1 + \;1.47\,K_2 + \;1.19\,K_3 - 17.78 &= 0\\ 1.47\,K_1 + 12.74\,K_2 + \;1.64\,K_3 + 16.01 &= 0\\ 1.19\,K_1 + \;1.64\,K_2 + 16.73\,K_3 + 17.42 &= 0\end{aligned}$$

From these we find that

$$K_1 = +1.67\,, \quad K_2 = -1.32\,, \quad K_3 = -1.03$$

and hence, from (3), we have

$$V = 2.36\,, \quad \sin\delta_0 = 0.708\,, \quad \tan\alpha_0 = +0.780$$

$$\delta_0 = 45^\circ.0 \quad , \quad \alpha = 218^\circ$$

(The quadrant in which α lies is determined by the signs of K_2 and K_3.)

The substantial agreement between these results and those obtained by the conventional method is very satisfactory; and whatever may be thought of the accuracy of the present results, it cannot be denied that they prove beyond question the *reality* of the sun's motion, and that they further indicate that our previous knowledge of the direction of this motion is approximately correct. So far as the sun's actual velocity is concerned, I think the spectroscopic method of finding it is immensely superior to the proper-motion method, on account of its freedom from questionable assumptions. The sum of the squares of the observed velocities in the line of sight is 290.99, and the sum of the squares of the residuals in the last column of the table is 222.37. This is as great a difference, perhaps, as could be expected. It may be well to state that the unit of length employed by Dr. Vogel in stating his results is the German geographical mile, which is equal to $\frac{1}{15}$ of an equatorial degree. Hence the velocity of the sun, as found above, is 10.9 English statute miles per second.

Hartford, Conn.

NOTE UPON SAWYER'S NEW VARIABLE IN *AQUILA* (6834 *V AQUILAE*).

$\alpha = 18^h\ 56^m\ 40^s, \qquad \delta = -5^\circ\ 53'\ 7''$ (1855.0)

By H. KREUTZ.

The variability of the deep red star DM. $-5^\circ 4858$ = Weisse I $18^h 1442$, which E. F. Sawyer announces in *A.J.* 290, has been already known for a long time. The notices concerning it, so far as they occur in the sources accessible to me, I permit myself to communicate herewith in brief.

Knott. *Astr. Nachr.* 1862, 1871 Sept. 16. "Its magnitude is certainly slightly variable."

Schönfeld. *Astr. Nachr.* 1905, 1872 Sept. 17. "I have seen the star a few times since 1863, and have compared it with a neighboring star, but without discovering changes of light."

Schmidt. *Astr. Nachr.* 1912, 1872 Oct. 11. "The red star Weisse 1442, I have observed almost every night since July 18. The tokens of its variability I have now recognized. It is diminishing very slowly, and seems to have a long period."

Schönfeld's second catalogue of Variable Stars (1874) mentions the star, on page 4 of the introduction, as probably variable.

Espin. Esp.-Birm. Catalogue of Red Stars, no. 584. "The star is certainly variable, and probably belongs to the 19 *Piscium* type."

Šafařik. *Astr. Nachr.* 2874, 1888 Nov. 15. "Slow, but decided change of light. A maximum 1884 March, and a minimum 1885 March, are indicated. Slow, moderate change of light, confirmed by numerous later observations."

Fleming. *Astr. Nachr.* 3011, 1890 Nov. 25. "Several photographs have been obtained with the 8-inch Draper telescope. The following approximate magnitudes, derived from an examination of these photographs, are 8.9, 9.0, 9.1, 8.2, 8.1, 8.2 and 8.1; the dates on which the charts were taken being June 26, July 20, Aug. 20, Oct. 22, Oct. 28, Nov. 4 and Nov. 18, 1890. Although the range of variability is not great . . . . the variation is still undoubted; the star appearing brighter than the adjacent stars on some of the charts, and fainter on others."

Kiel Observatory, 1893 *April* 18.

NOTE ON 6834 *V AQUILAE*.

By EDWIN F. SAWYER.

The preceding note of Prof. Kreutz, relative to this star, makes a few remarks desirable, as to cases of this kind which are continually arising.

It does not require a very large acquaintance with the periodical literature of astronomy to show that a considerable proportion of the brighter stars have, at one time or another, been suspected of variability. It is also a fact, equally familiar to all observers who have undertaken the task of following up these cases, that in almost every instance they prove, on investigation, to be constant. This has been so nearly the invariable result that experienced observers soon learn to distrust and avoid this whole mass of unverified and loose suggestion.

As enforcing this point, I am permitted to mention the fact that Dr. Chandler, who, a few years ago, had prepared at great labor a complete collection of references of this sort, from all sources embracing astronomical history up to the present time, was led, from a conviction of its utter uselessness, to suppress its publication, as being not worth the paper and ink, and indeed a stumbling block, rather than a means of assistance, to those interested in the subject of variable stars. One of the lists which has been quoted in connection with the present case affords a good illustration in point, containing a large number of suggestions of the sort, without apparent basis, and which careful examination by direct observation has failed to verify. Since observers who have occupied themselves with the verification of variability announced as discovered by photographic means, have hitherto met with singular want of success in confirming a large proportion of them, it seems as if we must for the present hesitate to accept evidence from photographic plates, at least in regard to fluctuations within the range of a magnitude, and probably even considerably more.

One other unfortunately selected reference may be alluded to, where the star is classed as "certainly variable and probably belonging to the 19 *Piscium* type." This last-named star has been proved, by the independent observations of at least two trustworthy observers, to be certainly constant.

It would seem desirable in the future for discoverers of supposed variable stars, — especially in cases where the range of fluctuation is less than a single unit of magnitude, and the color intense, — to obtain the independent judgement of at least one experienced observer before announcing such discovery. By so doing, proper attention would be secured for such cases; whereas at present, many announcements of the kind are passed by as being either very doubtful or worthless.

Brighton, Mass., 1893 *May* 26.

ON THE CONSTANT OF ABERRATION,

By S. C. CHANDLER.

V.

§9. Pulkowa Vertical-Circle Observations of Ten Stars, 1863–73.

Among the results of the foregoing series, that of §4 is especially remarkable. Inherently its excellence is indisputable, and would apparently give it a high weight. Yet the result for the aberration stands entirely apart from the rest. This fact aroused a natural suspicion that the discussion itself might be wrong; but a repetition by a different process led to the same numerical result. It consequently became interesting to inquire what aberration would result from simultaneous observations of other stars, by the same observer and instrument. I therefore selected the following ten stars from vol. XIV of the *Pulkowa Observations*, which appear to me to embrace everything not heretofore utilized for the purpose in the work with this instrument.

Table VIII gives the values of n found from the "Mean Declinations for 1865.0"* with the following assumed values of δ'_0,

	° ′ ″		° ′ ″
α Androm.,	+28 20 41.59	*α Coronae*,	+27 10 15.03
α Persei,	+49 22 39.76	*α Cygni*,	+44 47 56.92
η Urs. Maj.,	+49 59 16.80	*β Urs. min.*,	+74 42 26.03
α Bootis,	+19 53 11.60	*δ Urs. min.*,	+86 36 14.95
α Lyrae,	+38 39 35.01	*β Cephei*,	+69 58 6.67

The observations used are all Gyldén's, except those of *δ Ursae minoris*, marked with an asterisk in Table VIII. These values of n were then corrected by adding the assumed correction for the latitude-variation (*A.J.* 296, p. 63),

$$\varphi_0-\varphi = +0''.204\cos(t-1870\text{ Feb. }23)\times 0^\circ.843 + 0''.131\cos(\odot-309^\circ.8)$$

This equation represents all the Vertical-Circle observations from 1863–75 practically as well as (41) and (42), which were derived from Gyldén's and Nyrén's *Polaris* observations separately. With the values of n thus corrected, a solution was made for each polar star according to (29), putting y and $z=0$; and for the other stars according to (40). Instead of writing the resulting normal equations in the usual way, the coefficients are tabulated, for compactness, in a similar manner to those in §7, as follows:

	[aa]	*[ab]*	*[ac]*	*[an]*	*[bb]*	*[bc]*	*[bn]*	*[cc]*	*[cn]*
				″			″		″
α Andromedae,	+19.00	−7.00	−1.60	+1.09	+ 8.50	+1.28	+0.17	+10.51	+0.51
α Persei,	+16.00	−0.10	+6.94	+3.19	+ 7.05	−2.03	+1.80	+ 8.97	+1.33
η Ursae Majoris,	+16.00	+9.28	−2.66	−0.38	+10.58	+2.48	−0.25	+ 5.42	+0.12
α Bootis	+19.00	+8.79	−4.10	+1.21	+12.86	+2.14	−2.34	+ 6.14	−2.94
α Lyrae,	+17.00	−2.33	−4.14	−0.08	+11.11	−1.97	−0.63	+ 5.89	−1.06
α Coronae,	+13.00	+1.62	−2.95	−0.08	+ 9.49	+2.02	+0.68	+ 3.52	+0.07
α Cygni,	+16.00	−2.15	−9.05	−1.40	+ 5.77	−1.21	+0.72	+10.23	+0.72
β Ursae minoris,	. . .	. . .	. . .	. . .	+12.15	+3.00	−0.90	+ 7.98	−2.02
δ Ursae minoris,	. . .	. . .	. . .	. . .	+ 1.63	+0.57	−0.62	+ 5.34	−0.68
β Cephei,	. . .	. . .	. . .	. . .	+ 4.70	−0.89	−0.11	+ 6.92	+0.97

The solution gives the following:

	X	Y	w_1	Z	w_2
	″	″		″	
α Androm.,	+0.0951	+0.0905	5.88	+0.0520	10.30
α Persei,	+ .1613	+ .2822	6.39	+ .0850	5.40
η Urs. Maj.,	+ .0059	− .0388	1.95	+ .0429	1.87
α Bootis,	+ .0467	− .1480	5.70	− .3961	3.40
α Lyrae,	− .0920	− .1269	9.47	− .2871	4.28
α Coronae,	− .0299	+ .0886	7.29	− .0559	2.24
α Cygni,	− .0497	+ .1149	4.33	+ .0104	4.04
β Urs. min.,	. . .	− .0127	11.02	− .2484	7.24
δ Urs. min.,	. . .	− .3509	1.57	− .0902	5.15
β Cephei,	. . .	+0.0028	4.59	+0.1404	6.75

By (27), (37) and (38), we then have the following equations of condition for the several stars:

					w_0
				″	
α Androm.,	$+0.475d\eta$	$+0.347d\zeta$	$+0.346u$	$= +0.061$	20.0
α Persei,	$+\ .501$	$-\ .264$	$+\ .321$	$= +\ .119$	19.2
η Urs. Maj.,	$-\ .691$	$+\ .559$	$+\ .790$	$= +\ .051$	2.4
α Bootis,	$-\ .287$	$+\ .541$	$+\ .375$	$= -\ .172$	9.9
α Lyrae,	$+\ .088$	$+\ .878$	$+\ .779$	$= -\ .263$	5.5
α Coronae,	$-\ .280$	$+\ .685$	$+\ .548$	$= -\ .063$	4.5
α Cygni,	$+\ .446$	$+\ .783$	$+0.812$	$= +\ .083$	5.1
β Urs. min.,	$-\ .708$	$+\ .706$	$+1.000$	$= -\ .166$	8.7
δ Urs. min.,	$+\ .068$	$+\ .937$	$+0.883$	$= -\ .108$	5.8
β Cephei,	$+0.737$	$+0.670$	$+0.992$	$= +0.096$	5.4

whence result the normal equations,

$$\begin{array}{rrrl} +20.038\,d\eta & -\ 1.733\,d\zeta & +\ 3.586\,u & = +3''.637 \\ -\ 1.733 & +28.755 & +27.104 & = -3.455 \\ +\ 3.586 & +27.104 & +33.883 & = -1.833 \end{array}$$

the solution of which gives

$$d\eta = +0''.1523\,,\quad d\zeta = -0''.1820\,,\quad u = +0''.0753$$

The value of u gives the definitive value of the aberration according to this series,

20″.520

Thus the aberration from these ten stars contradicts that deduced from Gyldén's observations of *Polaris*, but is in excellent accord with the other determinations.

Putting the above values of $\delta\eta$ and $\delta\zeta$ for η and ζ in (36), we have the aberration-constant as given by the several stars:

	″		″
α Andromedae,	20.595	*α Coronae*,	20.635
α Persei,	20.428	*α Cygni*,	20.639
η Ursae Majoris,	20.771	*β Ursae minoris*,	20.519
α Bootis,	20.366	*δ Ursae minoris*,	20.504
α Lyrae,	20.295	*β Cephei*,	20.551

The values of the residuals (O—C) given in column v, Table VIII, are those which come from a substitution, in the equations of condition, of values of Y and Z found from (28) using the above values of $d\eta$, $d\zeta$ and u, and new values of X for each star.

---

*Four observations rejected: *α Persei* and *α Bootis* on 1863 Dec. 28, *β Ursae minoris* s.p. on 1864 June 4, *β Cephei* s.p. on 1867 Apr. 24.

Table VIII. Vertical-Circle Observations of Ten Stars, 1863–73.

t	n	v
α Andromedae.		
	″	″
63 Dec. 14	—0.19	—0.08
15	+ .02	+ .11
20	— .46	— .30
64 Feb. 22	— .48	— .10
24	— .30	+ .08
27	— .05	— .09
Mar. 2	+ .01	+ .38
5	+ .17	+ .54
May 13	— .01	.00
June 16	+ .18	— .05
Oct. 5	+ .37	— .04
7	+ .15	— .25
Nov. 6	+ .18	— .08
Dec. 7	+ .44	+ .38
65 Sept. 7	— .14	— .45
23	+ .23	— .05
Dec. 6	+ .21	+ .18
67 Oct. 25	— .45	— .38
29	+0.08	+0.18
α Persei.		
	″	″
63 Dec. 16	—0.10	—0.17
64 Jan. 31	— .32	— .12
Feb. 19	+ .52	+ .75
23	— .02	+ .20
24	— .15	+ .07
27	— .53	— .30
Mar. 2	— .02	+ .20
3	— .19	+ .03
Apr. 16	+ .36	+ .39
June 4	+ .77	+ .44
July 3	+ .29	— .26
6	+ .26	— .31
Nov. 3	+ .15	— .35
65 Mar. 3	— .43	— .37
May 9	+ .23	+ .06
Aug. 9	+0.26	—0.28
η Ursae Majoris.		
	″	″
64 June 2	—0.47	—0.34
3	— .14	— .01
5	— .17	— .05
6	— .11	.00
10	+ .63	+ .71
14	— .42	— .36
15	— .14	— .08
20	— .04	— .01
21	+ .24	+ .26
30	— .04	— .07
Sept. 19	— .11	— .36
20	+0.09	—0.16
η Ursae Majoris. — Cont.		
	″	″
64 Oct. 5	+0.38	+0.16
6	+ .19	— .03
Nov. 6	+ .27	+ .15
65 Apr. 22	—0.19	+0.11
α Bootis.		
	″	″
63 Nov. 18	+0.72	+0.69
28	+ .31	+ .36
64 May 31	— .06	— .01
June 1	+ .01	+ .06
15	+ .24	+ .20
21	— .13	— .21
23	— .19	— .29
29	— .53	— .66
July 5	— .09	— .26
Oct. 5	+ .70	+ .41
6	+ .24	— .05
65 Apr. 22	— .60	— .39
May 19	— .83	— .71
22	— .39	— .28
July 17	+ .11	+ .02
18	.00	— .05
24	+ .38	+ .28
Oct. 12	+ .91	+ .79
19	+0.30	+0.19
α Lyrae.		
	″	″
63 Nov. 29	+0.34	+0.42
Dec. 9	+ .43	+ .57
15	— .27	— .08
19	+ .35	+ .57
20	— .13	+ .10
64 Jan. 4	— .24	+ .07
Feb. 6	— .88	— .46
8	— .34	+ .08
June 6	— .10	— .14
July 5	+ .23	+ .02
14	— .06	— .30
Sept. 4	+ .29	— .06
15	+ .25	— .08
19	+ .46	+ .14
Oct. 5	+ .37	+ .09
65 July 17	— .27	— .39
18	—0.44	—0.56
α Coronae.		
	″	″
63 Nov. 28	0.00	+0.07
Dec. 14	+ .15	+ .35
64 May 31	— .21	— .14
June 1	— .15	— .08
Oct. 14	+0.09	—0.14
α Coronae. — Cont.		
	″	″
64 Oct. 20	—0.03	—0.24
65 May 9	— .33	— .16
July 17	+ .18	+ .11
20	+ .24	+ .17
24	— .07	— .15
Nov. 27	+ .32	+ .36
28	— .43	— .39
66 June 2	+0.25	+0.21
α Cygni.		
	″	″
63 Dec 31	—0.33	+0.10
64 Feb. 9	— .15	+ .41
Aug. 2	+ .11	— .10
5	+ .08	— .14
13	+ .06	— .17
Sept. 7	— .27	— .50
23	+ .26	+ .06
Oct. 5	+ .18	+ .02
13	— .14	— .27
Nov. 3	— .10	— .13
24	— .49	— .40
65 Aug. 1	— .05	— .08
Sept. 18	+ .32	+ .28
Oct. 12	+ .08	+ .10
19	+ .47	+ .51
66 Feb. 1	+0.02	+0.30
β Ursae minoris.		
U.C.	″	″
63 Nov. 18	+0.23	+0.07
28	+ .07	— .02
Dec. 14	— .07	— .03
64 July 5	+ .11	— .14
14	+ .08	— .20
Aug. 8	+ .37	— .01
Oct. 14	+ .50	+ .13
28	+ .66	+ .33
65 May 10	— .35	— .29
18	— .08	— .04
22	— .27	— .25
Oct. 12	+ .49	+ .26
Nov. 27	+0.33	+0.21
L.C.		
64 Feb. 27	—0.71	—0.37
Mar. 2	— .27	+ .06
3	— .21	+ .12
Apr. 16	+ .23	— .01
July 3	+ .05	— .18
6	+0.13	— .12
Nov. 1	+1.07	+ .76
3	—0.09	— .39
65 May 9	0.00	+0.07
δ Ursae minoris.		
U.C.	″	″
65 July 19	—0.02	—0.09
24	— .23	— .31
Sept. 21	+ .19	+ .10
22	— .13	— .22
66 Sept. 24	+ .11	+ .17
25	— .17	— .11
67 Oct. 14	+ .64	+ .82
69 Sept. 12	+ .07	— .26
71 July 5*	— .02	— .07
13*	— .62	— .71
20*	— .25	— .36
27*	— .42	— .56
Aug. 4*	— .30	— .46
72 July 29*	+ .27	+ .27
73 July 3*	—0.16	—0.18
L.C.		
64 Mar. 6	—0.85	—0.39
66 Mar. 10	+ .18	+ .33
16	— .12	+ .01
Sept. 23	+ .06	.00
25	— .18	— .12
72 Mar. 5*	— .40	— .02
6*	— .19	+ .18
22*	— .07	+ .28
73 Feb. 23*	+ .61	+ .85
24*	+ .11	+ .34
Mar. 15*	—0.08	+0.12
β Cephei.		
U.C.	″	″
64 June 16	0.00	—0.13
Aug. 2	— .06	— .45
13	+ .52	+ .17
27	+ .53	+ .17
Sept. 7	+ .02	— .33
23	+ .41	+ .11
Oct. 3	+ .20	— .07
13	— .13	— .36
Nov. 3	— .10	— .22
66 Jan. 31	+ .33	+ .53
Feb. 1	+ .23	+ .43
67 Nov. 15	+0.06	+0.40
L.C.		
65 May 4	—0.26	—0.14
9	— .46	— .37
Sept. 6	— .19	— .37
66 Apr. 11	+ .41	+ .44
14	+ .28	+ .30
67 Apr. 26	+0.16	0.00

§10. General Result for Aberration from Foregoing Sections.

In finishing the examination of the magnificent storehouse of material furnished by the Pulkowa vertical-circle and prime-vertical observations, and before going on to the work of other Observatories, a few remarks with regard to the general result for the aberration-constant are appropriate. Summarizing the values deduced in the various sections, we have:

VERTICAL CIRCLE.

				″
§2	PETERS,	*Polaris*	1842–44	20.510
4	GYLDÉN,	"	1863–69	20.411
5	NYRÉN,	"	1871–73.4	20.515
5	NYRÉN,	"	1873.5–75.5	20.508
3	PETERS,	7 stars	1812–43	20.467
9	GYLDÉN (mostly)	10 "	1863–73	20.520

PRIME-VERTICAL.

§6	STRUVE,	7 stars	1840–42	(20.514) (20.474)
8	NYRÉN,	4 "	1875–79	20.534
9	NYRÉN,	24 "	1879–82	20.516

The proper combination of these values is a delicate matter, the question of relative weights being one in which computed probable errors are subordinate to probable freedom from constant errors; thus a matter of instinct rather than calculation. While opinions may differ on some of the points involved, I think it will be agreed, after a thoughtful consideration of the sources of error of a possible periodical kind, most to be feared, that these are likely to have been best eliminated in NYRÉN's Prime-Vertical series, which therefore should be assigned a very high relative weight. A general inspection indicates without much doubt that a value close to 20″.51 would be arrived at, if it were not for the singular discordance of §4.

It is difficult to say whether we are authorized, merely on the ground of discordance, to suspect that this series may be affected by some peculiar error. I can imagine no other reason, either inherent in the observations or the computations; yet the matter is so important, and the value 20″.411 is so much below that reached by NYRÉN, 20″.169, that I should be glad to see an independent discussion of this series made.

If we collect the results for the individual stars from the various sections, the general mean, without regard to weight, of the 21 vertical-circle values is 20″.511, and of the 35 prime-vertical values, 20″.515. If we assume that all are equally well freed from the effects of the latitude-variation, and employ the relative weights $w = w_0(p^2-q^2)^2$, we find the following mean values from various combinations of the data:

				″
Vertical Circle,		*Polaris*,	§§2, 4, 5,	20.463
"	"	*Polaris*, (rej. §4)	2, 5,	20.512
"	"	Other than *Polaris*,	3, 9,	20.493
"	"	All,	2, 3, 4, 5, 9,	20.479
"	"	All except §4,	2, 3, 5, 9,	20.499
Prime-Vertical,		NYRÉN,	7, 8,	20.525
"	"	All,	6, 7, 8,	20.507

The combined weights for all the vertical-circle and prime-vertical observations are 225 and 309, respectively, on the same unit of accidental error of a single observation. Taking into account, however, the superior intrinsic accuracy of the latter as regards accidental error, and their greater probable freedom from systematic error, and combine the results,

	″	
All vertical-circle observations,	20.479	wt. 1
All prime-vertical observations,	20.507	3

we have the definitive aberration,

20″.500

I am not sure however, that a somewhat larger value might not be chosen with advantage, say 20″.505. But the rounded tenth will probably satisfy the most exacting requirements of practical accuracy in the reduction of the most refined astronomical observations. Combined with MICHELSON's measurement of the velocity of light it gives the solar parallax,

8″.794

and the corresponding light-equation,

$498^s.92$

NEW VARIABLE STAR IN *CARINA*,

BY EDWARD C. PICKERING.

At the request of Mr. ALEX. W. ROBERTS of Lovedale, South Africa, I beg to announce the variability of the star, Cordoba Z.C. VIII, 2388, magnitude 9, whose position for 1875 is in R.A. $8^h\ 28^m\ 34^s$, Decl. —58° 48′ 10″.

Mr. ROBERTS finds this star at minimum equal to a star following it 14^s, north 1′, and at maximum equal to A.G.C. 11612, magnitude 7¾. He gives the period 6.3 days, the light increasing during 2.0 days, and diminishing during 4.3 days. An examination of the photographs of this Observatory taken in Peru has been made by Mrs. FLEMING, which confirms the variability of this star. The results are given in the annexed table. The date is followed by the Greenwich mean time and the photographic magnitude.

Date	G.M.T. h	Mag.	Date	G.M.T. h	Mag.
1889 Dec. 9	19.7	7.6	1890 May 7	12.1	8.0
10	19.5	7.6	1891 May 16	13.3	8.3
1890 May 1	15.3	8.2	1892 Mar. 17	15.2	7.5
2	12.4	8.0	Apr. 24	12.8	7.6
2	13.3	8.0	May 19	12.0	7.6
2	14.1	8.2			

Harvard College Observatory, 1893 *May* 9.

PERIODIC COMET 1886 VII = 1893 *a*,

Mr. Schulhof of Paris has sent to the *Astronomische Nachrichten* an ephemeris of this comet, which the observation at the Cape of Good Hope, made May 18 by Mr. Finlay, the original discoverer, shows to have been extremely correct. The observed right-ascension gives the time of perihelion as $0^d.591$ later than that of Mr. Schulhof's elements, while the declination gives it as $0^d.600$ later.

In no. 3161 of the *Nachrichten* is a continuation of the ephemeris, which it seems desirable to reprint. Its correction, corresponding to a delay of $0^d.6$ in the perihelion-passage, will be

	$\Delta\alpha$	$\Delta\delta$
	m s	′
1893 June 4	+1 48.3	+13.0
13	1 47.4	12.3
22	1 43.5	10.9
July 1	+1 38.4	+ 9.1

Ephemeris for Paris Mean Midnight.

1893	α	δ	log Δ	$1:r^2\Delta^2$
	h m s	° ′		
June 7.5	1 8 18	+ 4 11.3	0.0746	0.573
8.5	12 56	4 40.6		
9.5	17 35	5 9.9		
10.5	22 15	5 39.1	0.0722	0.600
11.5	26 56	6 8.2		
12.5	31 38	6 37.1		
13.5	36 20	7 5.9	0.0707	0.624
14.5	41 3	7 34.5		
15.5	45 47	8 2.9		
16.5	50 31	8 31.2	0.0701	0.644
17.5	1 55 15	8 59.1		
18.5	2 0 0	9 26.8		
19.5	4 45	9 54.2	0.0703	0.662
20.5	9 30	10 21.3		
21.5	14 16	10 48.1		
22.5	19 1	11 14.5	0.0714	0.676
23.5	23 47	11 40.6		
24.5	2 28 33	+12 6.3		
June 25.5	2 33 19	+12 31.6	0.0733	0.685
26.5	38 4	12 56.5		
27.5	42 50	13 21.0		
28.5	47 35	13 45.1	0.0758	0.690
29.5	52 20	14 8.7		
30.5	2 57 5	14 31.9		
July 1.5	3 1 49	14 54.6	0.0790	0.691
2.5	6 33	15 16.9		
3.5	11 16	15 38.6		
4.5	16 0	15 59.9	0.0828	0.688
5.5	20 42	16 20.6		
6.5	25 24	16 40.9		
7.5	30 5	17 0.6	0.0870	0.681
8.5	34 46	17 19.8		
9.5	39 25	17 38.5		
10.5	44 4	17 56.7	0.0917	0.669
11.5	48 42	18 14.3		
12.5	53 19	18 31.4		
13.5	3 57 55	18 48.0	0.0968	0.654
14.5	4 2 29	19 4.0		
15.5	7 3	19 19.4		
16.5	11 35	19 34.3	0.1021	0 636
17.5	16 5	19 48.7		
18.5	20 35	20 2.6		
19.5	25 3	20 15.9	0.1076	0.616
20.5	29 30	20 28.6		
21.5	33 55	20 40.9		
22.5	38 19	20 52.6	0.1133	0.594
23.5	42 41	21 3.9		
24.5	47 2	21 14.6		
25.5	51 21	21 24.8	0.1190	0.570
26.5	55 38	21 34.5		
27.5	4 59 54	21 43.8		
28.5	5 4 9	21 52.5	0.1248	0.545
29.5	8 21	22 0.8		
30.5	12 32	22 8.6		
31.5	16 42	22 16.0	0.1307	0 520
Aug. 1.5	20 49	22 22.8		
2.5	24 54	22 29.3		
3.5	5 28 58	+22 35.2	0.1365	0.494

NEW ASTEROIDS.

Prof. Krueger has sent notice of three more small planets, found photographically by Mr. Charlois. Their positions were,

			α	δ	Daily Motion
		h m	h m s	° ′ ″	
1393 *Z*	12M	May 19 9 18.0 Nice M.T	14 35 45.27	—17 3 20	—44s in α, and 3′ northward.
AA	11	20 10 38.4 " "	15 56 39.20	—18 20 48	—68s " 2′ "
AB	13	20 10 42.9 " "	16 1 10.47	—18 10 45	—44s " 5′ "

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Note upon Sawyer's New Variable in Aquila (6834 *U* Aquilae), by Prof. H. Kreutz.
Note on 6834 *U* Aquilae, by Mr. Edwin F. Sawyer.
On the Constant of Aberration, V, by Dr. S. C. Chandler.
New Variable Star in Carina, by Prof. Edward C. Pickering.
Periodic Comet 1886 VII = 1893 *a*.
New Asteroids.

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MAXIMA AND MINIMA OF VARIABLE STARS, OBSERVED IN 1892–93,

By PAUL S. YENDELL.

112. *R Andromedae.*

Nineteen observations of this star, from 1892 Nov. 13 to 1893 Mar. 13, show a maximum of $6^{M}.4$ on 1893 Jan. 14. The increase was rapid and regular from the first observation until Dec. 9, when it had arrived at nearly its maximum light; from this time until observations were discontinued, the curve was flat, and the rise and decrease very slow. Its magnitude when last observed was $7^{M}.3$.

6404. *Y Ophiuchi.*

I have twenty-one observations of this star, from 1892 May 28 to Aug. 15; they are considerably interrupted by weather and moonlight, and yield only three maxima and two minima, as follows:

Maxima	w	Minima	w
1892 June 6.6	3	1892 June 16.0	3
22.0	3	July 21.4	4
Aug. 13.6	1		

6733. *R Scuti.*

From 1892 July 11 to Nov. 20, I observed *R Scuti* fifty-four times. My observations show maxima and minima as follows: Maxima, July 18, $4^{M}.2$, and Sept. 6, $5^{M}.3$; minima, Aug. 17, $6^{M}.2$, and Oct. 23, $6^{M}.4$. When last observed, on Nov. 20, it had risen to $4^{M}.2$.

7149. *S Sagittae.*

This star has been watched during nearly the whole season, the observations from 1892 May 16 to Dec. 11, numbering eighty, which yield nineteen maxima and ten minima, as follows:

Maxima	w	Minima	w
1892 May 17.42	1	1892 May 28.80	4
June 2.89	3	June 9.60	3
14.10	2	July 11.20	4
July 7.40	4	19.20	4
15.50	4	27.30	4
21.21	2	Aug. 3.70	4
31.10	3	20.90	4
Aug. 18.00	4	28.30	4
Aug. 24.76	2	Sept. 6.20	4
Sept. 2.79	2	16.00	3
11.40	5		
20.20	4		
27.10	4		
Oct. 6.47	1		
13.02	4		
25.63	3		
Nov. 11.36	1		
17.30	1		
Dec. 11.41	1		

7437. *X Cygni.*

My observations of *X Cygni* for this season extend from 1892 May 16 to 1893 Jan. 13, and number in all one hundred and twenty. From these are deduced fifteen maxima and twelve minima, whose dates and observed lights are given below, the light-scale being the same as for those published last year.

Maxima	w	Lt.	Minima	w	Lt.
1892 May 21.3	3	12.4	1892 May 26.7	5	6.1
June 7.1	4	13.4	June 15.0	4	6.9
22.8	4	13.4	July 4.3	3	7.2
July 8.1	4	12.4	18.3	4	5.1
23.9	5	13.4	Aug. 6.6	4	6.2
Aug. 11.9	1		17.2	4	7.2
27.2	1		Sept 22.4	4	5.0
Sept. 11.3	5	13.4	Oct. 10.6	4	5.1
27.7	4	12.4	23.8	4	3.0
Oct. 14.3	4	11.4	Nov 11.5	4	5.1
29.6	4	10.1	Dec. 11.4	4	2.0
Nov. 17.0	4	9.4	25.5	4	5.1
Dec. 3.2	3	12.2			
19.3	4	10.4			
1893 Jan. 1.5	3	12.2			

The existence of the long-period fluctuations in the light-range of the star seems to be still further confirmed by the progression shown in the observed degrees of light given above: a maximum occurring in both maximum and minimum light at E 129, and a minimum in the maximum light at E 136, and in the minimum at E 138.

7483. *T Vulpeculae.*

This star was observed seventy-eight times during the season, from 1892 May 27 to Dec. 11. From these observations are deduced twenty-six maxima, and twenty-three minima, as follows:

Maxima	w	Minima	w
1892 June 7.74	2	1892 May 29.11	1
12.45	2	June 7.50	1
21.21	2	15.38	1
July 8.72	1	July 7.39	1
17.40	2	16.37	1
22.10	2	20 38	1
26.44	3	Aug. 7.35	1
30.36	1	16.36	1
Aug. 3.80	1	19.35	1
13.84	1	24.41	1
17.49	2	Sept. 1.87	2
21.34	1	10.31	1
Sept. 8.64	2	17.43	2
12.19	2	21.73	2
17.47	1	24.96	1
26.90	3	Oct. 2.50	1
30.64	2	7.85	1
Oct. 10.68	2	12.64	2
14.60	1	21.30	1
18.25	1	30.79	1
23.35	3	Nov. 8.32	1
Nov. 5.81	1	18.41	1
10.11	2	21.36	1
18.78	1		
23.14	2		
Dec. 11.73	1		

6368. *X Sagittarii.*

This star was under observation in 1892 from June 12 to Oct. 1, the observations numbering forty-five; these yield ten maxima and four minima, as follows:

Maxima	w	Minima	w
1892 June 13.7	2	1892 July 23.4	4
21.3	2	Aug. 20.4	4
July 12.11	1	Sept. 10.9	4
18.8	4	19.3	4
26.2	4		
Aug. 1.2	2		
8.5	1		
16.4	4		
Sept. 7.2	4		
26.6	2		

Dorchester, Mass., 1893 *May* 28.

6172. *W Sagittarii.*

Forty-five observations of *W Sagittarii*, from 1892 June 15 to Oct. 2, indicate seven maxima and six minima, as follows:

Maxima	w	Minima	w
1892 July 16.5	4	1892 June 20.3	1
25.1	4	July 21.4	4
Aug. 15.5	4	Aug. 1.6	2
23.5	3	21.2	4
31.4	2	Sept. 6.4	1
Sept. 16.8	2	12.3	3
30.4	4		

6573. *Y Sagittarii.*

Y Sagittarii was observed forty-three times, from 1892 June 15 to Oct. 14. The observations indicate eleven maxima and six minima, as follows:

Maxima	w	Minima	w
1892 June 15.4	1	1892 July 22.8	4
July 19.5	4	29.0	3
25.5	4	Aug. 15.1	4
Aug. 17.5	4	21.1	4
23.3	3	Sept. 25.3	2
28.4	1	29.9	4
Sept. 9.1	3		
21.9	2		
27.0	3		
Oct. 2.29	1		
13.8	2		

6636. *U Sagittarii.*

This star has been observed forty times during the season, from 1892 June 15 to Oct. 2; from the observations are deduced ten maxima and seven minima, as follows:

Maxima	w	Minima	w
1892 June 14.3	1	1892 July 21.4	4
21.3	1	28.4	4
July 17.4	4	Aug. 17.4	4
24.4	4	23.8	3
31.2	1	Sept. 11.5	4
Aug. 7.5	1	20.6	3
13.4	1	27.3	3
Sept. 9.5	2		
16.8	2		
30.5	2		

THE COMET OF HOLMES, 1892 III,

By LEWIS BOSS.

The recorded fluctuations in the brightness of Comet 1892 III, appear to warrant an attempt to observe it during the coming opposition. On the one hand, the chance of seeing it may be considered to be small, since according to the usual formula its theoretical brightness at no time this year should quite attain three-fourths of that which it had in March last. On the other hand, unusual interest attaches to the question whether remarkable alterations in the brilliancy of this comet are still to recur. Furthermore, it might be of interest to find out what is probably the normal physical appearance of this comet. At present it would not be entirely safe to say that this appearance may not be that of a minute star-like mass, though the probabilities might be considered to favor the hypothesis that this comet is normally a diffused nebulosity of great extent, as it appeared to be in December last.

The elements published in *Journal*, No. 292, represent the places of the comet on March 9 and 10 with the following discrepancies (observed — computed) from determinations made on those dates at Strassburg.

Greenw. Corrected Time.				Δα	Δδ
	d	h	m	s	″
March	9	7	50	+0.42	—14.9
	10	8	5	+0.49	— 1.1

Therefore, the comet if it can be found at all, should be seen very near the predicted position. The following ephemeris begins at a date nearly two months in advance of that for which the conditions for seeing the comet can be regarded as favorable. Opposition will be in December.

Ephemeris of Comet 1892 III (Holmes),

Computed by C. S. Benton.

Greenw. M.T.		App. α			App. δ		log Δ
	1893	h	m	s	°	′	
July	17.5	6	38	49	+37	17.6	0.63239
	21.5	6	45	17	37	11.1	0.63218
	25.5	6	51	40	37	4.2	0.63172
	29.5	6	57	55	36	57.0	0.63101
Aug.	2.5	7	4	4	+36	49.5	0.63007
Aug.	6.5	7	10	5	+36	41.7	0.62887
	10.5	7	15	59	36	33.8	0.62743
	12.5	7	18	53	36	29.8	0.62662
	14.5	7	21	45	36	25.8	0.62574
	16.5	7	24	35	36	21.7	0.62480
	18.5	7	27	23	36	17.6	0.62380
	20.5	7	30	8	36	13.6	0.62274
	22.5	7	32	52	36	9.6	0.62162
	24.5	7	35	32	36	5.6	0.62044
	26.5	7	38	11	36	1.6	0.61919
	28.5	7	40	48	35	57.6	0.61789
	30.5	7	43	22	35	53.7	0.61653
Sept.	1.5	7	45	53	35	49.9	0.61511
	3.5	7	48	22	35	46.1	0.61362
	5.5	7	50	49	35	42.3	0.61208
	7.5	7	53	13	35	38.7	0.61048
	9.5	7	55	34	35	35.1	0.60882
	11.5	7	57	53	35	31.7	0.60710
	13.5	8	0	9	35	28.4	0.60533
	15.5	8	2	22	35	25.2	0.60349
	17.5	8	4	32	35	22.1	0.60161
	19.5	8	6	39	35	19.1	0.59966
	21.5	8	8	43	35	16.3	0.59766
	23.5	8	10	43	35	13.7	0.59562
	25.5	8	12	41	35	11.2	0.59351
	27.5	8	14	35	+35	8.9	0.59136

SUNSPOT OBSERVATIONS,

MADE AT PHILADELPHIA, PENN., WITH A 4½-INCH REFRACTOR,

BY A. W. QUIMBY.

1893	Time	New Grs	Total		Fac Grs	Def.
			Grs	Spots		
Jan. 2	9	1	5	51	4	fair
3	9	_	5	41	2	poor
4	9	3	8	29	3	poor
5	11	_	5	27	_	poor
6	1	_	5	36	3	poor
7	10	1	6	49	3	fair
8	1	_	5	26	3	poor
9	2	1	4	15	3	poor
10	11	1	3	5	_	v.poor
11	1	_	2	8	3	poor
13	9	_	2	11	3	fair
14	9	_	2	8	3	poor
15	10	1	3	14	1	poor
16	10	1	4	26	3	poor
17	10	_	4	32	_	poor
18	2	_	3	42	1	poor
19	9	_	3	79	3	fair
20	9	_	3	106	4	fair
21	12	2	4	98	4	fair
22	9	_	5	141	4	fair
23	10	_	3	_	_	v.poor
24	10	1	5	136	4	fair
25	10	1	7	97	4	fair
26	9	2	9	138	3	fair
27	10	_	7	28	_	poor
30	12	_	6	38	2	poor
31	12	1	8	68	3	fair
Feb. 1	1	_	5	22	_	v.poor
Feb. 3	2	_	4	33	2	poor
4	12	_	3	21	1	poor
5	10	2	6	29	4	poor
7	9	_	3	9	_	v.poor
8	10	2	6	73	3	fair
9	10	_	6	86	3	fair
11	12	2	6	45	2	poor
12	9	_	6	53	2	poor
14	3	_	4	108	2	fair
15	12	_	3	45	_	poor
16	10	2	4	82	3	fair
18	10	2	7	43	2	poor
19	10	_	6	30	2	poor
20	10	_	5	33	3	poor
21	10	1	5	30	3	poor
22	10	_	5	50	2	poor
23	12	_	3	31	2	poor
24	12	1	3	90	4	poor
25	1	_	5	117	3	fair
26	10	_	5	33	_	poor
27	8	1	5	44	3	poor
Mar. 1	10	1	7	70	3	poor
2	9	1	6	63	3	poor
3	3	1	4	43	3	poor
5	10	_	6	29	3	poor
6	1	_	4	31	2	poor
7	12	_	5	30	2	poor
8	7	_	5	20	2	poor
Mar. 12	8	_	1	9	2	poor
13	8	_	1	5	2	poor
14	8	_	1	6	1	poor
15	9	_	2	17	2	fair
16	9	2	4	10	3	poor
17	9	1	4	7	2	poor
18	9	1	5	26	3	fair
19	9	1	5	25	2	poor
20	10	_	5	31	_	poor
21	4	_	3	43	2	poor
25	9	1	4	77	3	fair
26	9	4	8	95	3	fair
27	2	_	6	29	3	poor
28	8	_	7	57	3	fair
29	_	_	7	85	3	fair
30	8	2	8	88	3	fair
31	8	1	8	63	4	fair
Apr. 1	9	_	6	60	3	poor
2	9	1	8	80	4	fair
3	8	2	9	47	3	poor
4	9	_	5	28	3	poor
5	8	1	5	13	3	poor
6	8	_	4	30	3	poor
7	8	_	3	9	1	v.poor
8	10	_	3	26	2	poor
9	9	1	4	71	2	fair
11	9	1	6	43	2	fair
13	9	_	5	13	_	v.poor

1893	Time	New Grs	Total		Fac Grs	Def.
			Grs	Spots		
Apr. 14	3	–	4	9	–	v.poor
15	10	–	6	23	3	poor
16	11	1	7	27	4	fair
17	8	1	6	25	3	poor
18	8	–	6	27	3	fair
19	8	2	7	49	4	fair
21	8	2	8	47	3	fair
22	8	2	9	43	4	fair
23	8	–	9	98	4	fair
24	8	1	8	130	4	fair
25	8	–	6	80	2	poor
26	8	–	6	67	3	poor
27	8	–	5	33	2	v.poor
28	8	1	7	59	3	fair
29	8	1	7	45	3	poor
30	8	–	4	17	–	v.poor
May 2	8	2	9	88	3	fair
4	5	1	9	70	2	poor
5	7	1	9	57	2	fair
6	7	1	8	105	3	good
7	7	1	8	54	3	poor
8	7	–	8	50	3	fair
9	12	–	8	23	3	fair
10	7	–	6	19	3	fair
11	7	1	8	12	2	fair
May 12	7	1	9	21	3	fair
13	7	1	7	11	2	poor
14	8	3	9	33	3	poor
15	8	–	8	23	2	poor
16	6	–	7	27	2	poor
17	8	–	7	19	2	v.poor
18	8	1	8	31	2	poor
19	7	–	5	50	5	fair
20	7	1	5	37	5	good
21	7	1	6	27	5	fair
22	7	1	8	48	4	fair
23	7	–	8	58	–	fair
24	7	–	7	85	3	fair
25	10	2	9	84	3	fair
26	10	–	6	90	4	fair
28	9	3	9	62	3	poor
29	2	–	7	56	3	poor
30	8	1	7	63	3	poor
31	7	–	6	78	4	fair
June 1	7	–	4	64	3	poor
2	7	–	3	65	4	poor
3	2	–	4	209	–	good
4	2	–	4	173	3	good
5	7	2	6	103	3	fair
6	7	1	7	136	4	poor
June 7	7	–	6	79	2	poor
8	7	–	5	87	4	fair
9	7	–	6	79	4	fair
10	7	–	4	52	3	fair
11	7	–	4	69	3	fair
12	8	–	4	57	4	fair
13	8	–	3	32	3	fair
14	3	2	6	32	3	poor
15	7	–	6	72	4	fair
16	7	–	5	57	2	poor
18	7	3	8	65	4	poor
19	7	–	5	31	4	poor
20	7	–	4	25	4	poor
21	7	–	3	42	2	poor
22	9	3	6	47	4	fair
23	2	–	7	72	3	fair
24	7	1	8	72	2	fair
25	8	1	7	64	2	fair
26	5	–	3	15	–	v.poor
27	2	–	2	13	–	v.poor
28	7	1	3	52	2	poor
29	7	1	5	54	2	poor
30	9	–	7	51	4	poor

OBSERVATIONS OF DOUBLE STARS

MADE IN 1892 AT THE OBSERVATORY OF THE CATHOLIC UNIVERSITY, WASHINGTON, D.C.,

BY REV. GEO. M. SEARLE.

Name of Star	No. of nights	Mean dec. of year	Position-angle	Distance	Name of Star	No. of nights	Mean dec. of year	Position-angle	Distance
			°	″				°	″
η *Cassiopeae*	3	.12	193.6	5.01	P. XIV 212	3	.40	294.0	16.07
α *Piscium*	1	.11	321.9	3.19	44 *Bootis*	3	.44	241.3	5.12
28 *Trianguli*	1	.11	245.2	7.74	δ *Serpentis*	4	.40	185.8	3.86
P.V 70	1	.11	108.4	3.36	ζ *Coronae*	3	.43	302.6	6.15
Σ3116	1	.17	29.4	4.68	Σ1985	3	.40	336.3	6.27
38 *Geminorum*	1	.11	158.1	6.19	49 *Serpentis*	3	.42	330.4	4.27
ε *Hydrae*	2	.15	223.1	3.72	σ *Coronae*	3	.41	208.1	4.27
γ *Leonis*	4	.13	113.2	3.68	λ *Ophiuchi*	1	.45	41.9	1.08
ξ *Ursae Majoris*	3	.43	193.2	2.00	ζ *Herculis*	2	.42	54.4	1.50
υ *Leonis*	3	.42	56.3	2.70	Σ2120	3	.43	246 6	6.88
Σ1669	3	.40	303.1	6.30	μ *Draconis*	4	.42	155.3	2 89
γ *Virginis*	4	.40	152.6	6.01	36 *Ophiuchi*	3	.43	195.2	4.56
P. XIII 127	2	.45	70.2	3.07	δ *Herculis*	2	.40	190.0	14.84
o *Virginis*	3	.40	229.8	2.35	ρ *Herculis*	3	.42	311.2	4.26
P. XIII 238	2	.40	72.6	3.17	Σ2190	3	.41	23.5	10.91
Σ1804	3	.41	19.4	4.42	τ *Ophiuchi*	3	.43	252.7	2.19
Σ1830	1	.46	318.5	6.61	70 *Ophiuchi*	3	.41	321.5	2.51
ε *Bootis*	4	.42	331.4	2.83	ε_1 *Lyrae*	3	.39	12.4	3.45
ξ *Bootis*	4	.38	238.8	3.14	ε_2 *Lyrae*	3	.39	130.7	2.64

The above measures were made with a double-image micrometer, constructed on the principle of CLAUSEN (*Astr. Nachr.* vol. XLI). The larger measures of distance are necessarily, on the theory of the instrument, somewhat untrustworthy, requiring great precision in the determination of the constants, and being probably more than proportionally effected by various causes of error.

SUNSPOT OBSERVATIONS,

MADE AT THE HAVERFORD COLLEGE OBSERVATORY WITH THE 10-INCH EQUATORIAL,

By GEORGE L. JONES.

1893	Time	Grs	Spots	Fac Grs	Def. and Size
Jan. 6	11	6	59	0	fair
7	11	7	66	3	good : f. lar.
8	1	5	45	2	fair : im. fac.
10	11	4	13	2	poor
11	10	2	14	2	fair
13	11	2	17	2	good
14	10	2	13	0	fair
15	11	2	17	0	fair
16	10	3	38	0	fair
17	3	4	53	1	good
18	11	2	40	0	bad
19	10	3	77	0	poor
20	11	3	95	3	good
21	12	4	128	3	good
23	4	4	79	0	fair
24	11	7	149	2	good
25	11	8	145	0	poor
26	10	10	226	3	good ; 4 lar.
30	12	4	64	0	poor ; 3 lar
31	2	6	75	1	poor ; 2 lar.
Feb. 3	2	5	63	2	fair
4	11	3	49	1	poor
5	9	6	41	3	bad ; 1 lar.
8	1	4	64	1	fair
9	10	5	80	2	fair
11	1	6	75	2	good ; 2 lar.
12	1	4	55	1	poor ; 1 lar.
14	9	3	91	0	poor ; 1 lar.
16	10	4	52	2	fair ; 1 lar.
18	11	6	48	2	fair
19	9	5	53	1	poor
20	10	5	57	2	bad
21	10	4	61	2	poor
22	4	3	61	1	bad ; 1 lar.
24	12	4	131	2	good ; 2 lar.
25	2	4	136	2	good ; 2 lar.
26	9	3	86	2	fair ; 2 lar.
27	8	5	66	1	fair : 2 lar.
Mar. 1	10	4	121	3	good ; 1 lar.
2	9	6	92	1	fair : 1 lar.
3	3	5	67	3	poor ; 1 lar.
5	10	5	54	2	poor
Mar 6	11	4	53	0	fair
7	2	5	62	1	fair
8	10	4	59	1	poor
12	11	2	30	1	fair ; 1 lar.
13	10	5	59	2	fair ; 1 lar.
14	10	5	67	3	fair ; 1 lar.
15	11	2	37	1	poor ; 1 lar.
16	11	3	22	3	poor ; 1 lar.
17	8	4	20	1	fair ; 1 lar.
18	8	3	29	1	fair ; 1 lar.
19	8	3	25	1	poor ; 1 lar.
20	1	3	49	2	good ; 1 lar.
21	3	4	99	3	good ; 2 lar.
25	10	4	63	1	poor ; 2 lar.
26	9	8	89	2	fair ; 3 lar.
27	3	5	64	2	fair ; 1 lar.
28	10	7	81	1	fair ; 2 lar.
29	9	7	73	2	poor ; 2 lar.
30	10	8	104	3	fair ; 1 lar.
31	11	7	78	2	fair
Apr. 1	9	6	93	0	poor
2	9	4	71	1	fair
3	10	3	62	3	good
4	4	4	41	3	good ; 1 lar.
5	1	4	20	1	fair
6	9	3	26	1	poor
9	1	5	77	0	good
11	11	4	68	2	poor ; 1 lar.
15	2	5	60	2	good ; 1 lar.
16	11	6	53	4	fair ; 1 lar.
17	9	4	43	1	bad ; 1 lar.
18	8	6	61	2	fair ; 1 lar.
19	8	5	71	1	fair ; 1 lar.
21	8	6	84	2	fair ; 1 lar.
23	11	6	132	3	good ; 1 lar.
24	8	7	189	2	good ; 1 lar.
26	1	5	91	1	poor
28	8	6	125	2	fair ; 1 lar.
29	10	7	79	0	fair
May 1	10	7	65	2	poor ; 1 lar.
5	9	6	108	4	fair : 1 lar.
6	9	6	97	3	fair ; 1 lar.
May 7	9	5	93	2	fair
8	8	6	72	3	fair
9	8	5	55	3	fair ; 1 lar.
10	9	4	32	2	good
11	9	7	40	2	fair
12	8	6	60	2	fair
13	8	5	36	3	poor
14	9	7	47	1	fair
16	7 PM	7	49	1	v. poor
19	9	4	57	2	good
20	9	5	60	4	good
21	10	4	48	2	good ; 2 lar.
22	10	5	32	2	fair
23	8	6	107	4	good ; 1 lar.
24	9	7	106	1	fair
25	8	8	162	2	fine
26	9	6	145	0	good ; 1 lar.
30	9	8	126	3	fair ; 2 lar.
31	8	7	122	2	fair ; 2 lar.
June 1	10	5	113	3	good ; 3 lar.
3	2	5	172	0	fair
4	2	6	245	0	v.good ; 1 lar.
5	3	9	267	2	fine ; 1 lar.
6	8	5	165	2	fair
7	3	7	144	2	poor ; 1 lar.
8	8	6	134	1	fair
9	3	6	121	4	fair ; 1 lar.
10	2	4	130	2	fine : 1 lar.
11	9	5	75	2	fair ; 2 lar.
12	10	4	109	0	fair ; 1 lar.
13	7 PM	4	70	0	bad
15	8	7	122	2	poor ; 1 lar.
18	5	6	105	5	fine
19	8	5	81	3	fair
20	11	2	44	1	fair
21	11	3	41	1	good
22	11	4	49	0	fair
23	4	6	115	1	good
24	9	9	89	3	fair
25	3	5	53	2	bad
29	9	6	61	0	poor
30	9	7	57	3	poor ; 1 lar.

The observations beginning with June 21st were made by W. H. COLLINS, Mr. JONES having left Haverford on the 20th.

ON THE VARIABLE STARS BIRM. 592 AND BIRM. 483.

By A. ŠAFAŘIK.

I beg to point out that the two red Variables in *Cygnus* and *Aquila*, announced as new in Nos. 284 and 290 of the *Astronomical Journal*, were discovered by me many years ago, and duly announced in my memoir "*Über den Lichtwechsel einer Anzahl Sterne aus der Bonner Durchmusterung und aus den Katalogen rother Sterne von Schjellerup und Birmingham*," which was printed in the *Sitzungsberichte der Kgl. Böhmischen Gesellschaft der Wissenschaften* (1886, pp. 326 to 392) and an abstract of it with additional remarks in the *Astron. Nachrichten*, no. 2874 (vol. 120).

In that communication twenty-two stars are discussed, eight of them being variable. The bright red star Birm. 467, only 4° distant from 483, which has escaped Mr. SAWYER's vigilance, is also variable: and in the vicinity is a third new variable, about which I have not yet published anything.

I possess ample materials for a second memoir on some fifty stars, perhaps one-quarter of them being variable: but from pressure of other work and from failing health I have not yet been able to prepare it for the press.

OBSERVATIONS OF COMET 1892 VI,

MADE WITH THE FILAR MICROMETER OF THE CORDOBA EQUATORIAL,

By R. H. TUCKER, Jr.,

[Communicated by Dr. JOHN M. THOME, Director.]

1893 Cordoba M.T.	✱	No. Comp.	☄ — ✱		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Feb. 6 15 39 52	1	8	+1 33.99	+ 0 46.3	17 7 53.01	—41 32 37.8	n9.784	n0.105
8 15 34 57	2	11	+0 41.10	+ 5 46.0	17 14 18.75	—41 21 4.8	n9.785	n0.130
9 15 31 25	3	11	—0 37.26	— 0 29.7	17 17 24.53	—41 14 54.2	n9.784	n0.134
10 15 37 27	4	13	+0 26.47	+ 4 31.3	17 20 28.21	—41 8 34.1	n9.779	n0.105
13 15 40 32	5	11	—0 50.82	— 3 29.6	17 29 14.23	—40 48 14.6	n9.771	n0.076
15 15 31 46	6	9	—0 54.10	— 0 59.3	17 34 45.47	—40 33 56.1	n9.776	n0.130
16 15 34 8	7	7	—1 54.42	— 5 38.0	17 37 25.25	—40 26 30.2	n9.774	n0.122
18 15 31 20	8	9	—0 6.85	— 7 56.0	17 42 34.47	—40 11 16.9	n9.772	n0.129
21 15 31 53	9	9	+0 30.46	+ 7 14.1	17 49 51.93	—39 47 42.5	n9.763	n0.098
Mar. 4 15 50 4	10	7	+2 15.01	— 2 49.6	18 12 11.11	—38 15 39.1	n9.705	n9.868
6 15 24 34	11	9	+0 36.73	—10 13.2	18 15 30.14	—37 58 42.3	n9.732	n0.048
7 15 30 50	11	7	+2 12.81	— 1 33.4	18 17 6.25	—37 50 2.4	n9.720	n9.991
9 15 34 17	12	6	—3 5.82	+ 4 30.8	18 20 8.76	—37 32 40.8	n9.707	n9.945
16 16 7 21	13	5	+2 26.45	— 5 8.1	18 29 9.01	—36 32 42.7	n9.608	n9.396

The observations have been corrected for differential refraction.

Mean Places for 1893.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	17 6 20.22	—1.20	—41 33 23.3	—0.8	Cordoba Zone Catalogue
2	17 13 38.80	—1.15	—41 26 49.7	—1.1	" " "
3	17 18 2.91	—1.12	—41 14 23.3	—1.2	Cordoba General Catalogue
4	17 20 2.83	—1.09	—41 13 4.1	—1.3	" " "
5	17 30 6.05	—1.00	—40 44 43.1	—1.9	" " "
6	17 35 40.51	—0.94	—40 32 54.6	—2.2	" " "
7	17 39 20.59	—0.92	—40 20 49.9	—2.3	" " "
8	17 42 42.19	—0.87	—40 3 18.3	—2.6	" " "
9	17 49 22.26	—0.79	—39 54 53.9	—2.7	" " "
10	18 9 56.53	—0.43	—38 12 46.0	—3.5	" " "
11	18 14 53.79	—0.38 —0.35	—37 48 25.5	—3.6 —3.5	" " "
12	18 23 14.88	—0.30	—37 37 8.0	—3.6	Cordoba Zone Catalogue
13	18 26 42.60	—0.04	—36 27 30.7	—3.9	Cordoba General Catalogue

Comparison with RISTENPART'S Ephemeris gives the corrections as $+2^s$ and $+0'.4$.

ANCIENT ECLIPSES AND CHRONOLOGY,

By W. T. LYNN, B.A., F.R.A.S.

In the last number of the *Astronomical Journal*, Prof. STOCKWELL returns to this subject by referring to two solar eclipses which occurred in A.D. 346 and 348, and which he thinks are in favor of his theory that the first years of Olympiads coincided with bissextile years. In the first place, let me point out several mistakes in his paper. He says that the former is mentioned by EUSEBIUS; the fact being that EUSEBIUS died about six years previously, in A.D. 340. He says that HIERONYMUS mentions both eclipses; he really speaks of only one, which he places in the 11th (not 12th) year of CONSTANTIUS. Most commentators think he meant the total eclipse of June 6, A.D. 346, which was the tenth year of CONSTANTIUS, as is proved by the eclipse of A.D. 360, which according to AMMIANUS MARCELLINUS, occurred the year before his death. THEOPHANES mentions two eclipses, one the year after the other, but evidently makes a mistake in this, as they must be those, as Prof. STOCKWELL remarks, of A.D. 346 and 348.

I will now show that there must be errors in the years of the Olympiads given in the Chronicon of EUSEBIUS, continued by JEROME. An eclipse is mentioned in the fourth year of NERO, which must have been the fifth (A.D. 59) in which the Emperor murdered his mother, AGRIPPINA; for the eclipse fell in April 30 of that year. This, according to EUSEBIUS, was the third year of the 209th Olympiad, which would make A.D. 61 (the year following a bissextile) an Olympic year. This agrees with my own view on the correspondence between Olympic and bissextile years. Now with regard to the eclipses in the reign of CONSTANTIUS. There can be little doubt that his accession was in A.D. 337, and his twelfth year, in which the battle of Singara was fought, began in A.D. 348. HIERONYMUS places the eclipse before (in some copies the year before) the battle, though that was certainly not so late in the year as October. It is somewhat uncertain, then, whether he means the eclipse of 346 or 348; and, as in THEOPHANES, there must be some mistake. Historical considerations seem to make it probable that it was the former eclipse falling in the year of SAPOR's second attack upon Nisibis. Whilst therefore recognizing the value of Prof. STOCKWELL's calculations of those eclipses, it would be well if he would reexamine their historical bearing and significance.

OBSERVATIONS OF COMETS,

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

1893 Cincinnati M.T.	*	No. Comp.	☄ — *		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
			COMET 1892 VI.					
h m s			m s	′ ″	h m s	° ′ ″		
June 6 11 19 39	1	8 , 8	—0 9.15	+1 26.6	17 41 1.10	—25 7 36.1	n9.228	0.891
7 9 57 7	2	5 , 5	—0 46.37	—6 43.3	17 39 41.67	—24 59 6.3	n9.502	0.863
9 57 7	1	4 , 4	—1 28.51	+9 54.5	17 39 41.74	—24 59 8.2	n9.502	0.863
10 9 45 34	3	6 , 6	+4 50.48	—0 46.0	17 35 34.89	—24 32 33.1	n9.489	0.864
12 9 20 30	4	6 , 6	—3 3.70	—0 57.4	17 32 56.44	—24 15 16.9	n9.522	0.856
16 11 9 48	5	4 , 4	+3 23.90	+5 0.7	17 27 45.03	—23 40 35.5	n8.885	0.893
11 9 48	6	3 , 3	+3 0.23	—5 49.9	17 27 44.94	—23 40 31.8	n8.885	0.893
18 13 46 9	7	8 , 8	+2 48.60	—1 44.7	17 25 13.13	—23 23 1.0	9.434	0.869
22 13 26 37	8	8 , 8	—2 56.27	+0 50.8	17 20 43.93	—22 51 14.6	9.434	0.866
			COMET 1886 VII (FINLAY).					
June 12 14 53 12	9	9 , 9	—0 26.16	—3 2.0	1 35 7.02	+ 7 0 2.3	n9.656	0.728
16 14 55 18	10	13 , 13	—0 41.21	+1 2.4	1 53 59.03	+ 8 53 11.7	n9.658	0.723
18 14 47 49	11	6 , 6	—3 21.63	—1 39.4	2 3 26.22	+ 9 48 3.3	n9.662	0.724
22 14 27 5	12	12 , 12	+1 1.39	—0 34.6	2 22 21.25	+11 34 16.0	n9.670	0.730
14 27 5	13	12 , 12	—0 48.66	+2 44.0	2 22 21.31	+11 34 19.5	n9.670	0.730

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	17 41 7.76	+2.49	—25 8 53.9	— 8.8	Gould Z.C. XVII. 2711
2	17 40 25.55	+2.49	—24 52 14.1	— 8.9	" XVII, 2670
3	17 30 41.90	+2.51	—24 31 37.7	— 9.4	" XVII, 2010
4	17 35 57.59	+2.55	—24 14 10.5	— 9.0	" XVII. 2381
5	17 24 18.53	+2.60	—23 45 26.3	— 9.9	Gould G.C. 23720
6	17 24 42.11	+2.60	—23 34 32.1	— 9.8	" 23735
7	17 22 21.91	+2.62	—23 21 6.2	—10.1	" 23671
8	17 23 37.57	+2.63	—22 51 55.4	—10.0	Gould Z.C. XVII. 1526
9	1 35 33.02	+0.16	+ 7 2 59.0	+ 5.3	Schj. 502; Eq. comp. with Glasg. 355
10	1 54 40.04	+0.20	+ 8 52 3.2	+ 6.1	Schj. 585–6
11	2 6 47.65	+0.20	+ 9 49 36.2	+ 6.5	Weisse II, 57(1), Rüm. 2, 1106(2)
12	2 21 19.64	+0.22	+11 34 43.8	+ 6.8	Weisse II. 310, Mün. 1, 937, Mün. 2, 555*
13	2 23 9.76	+0.21	+11 31 28.6	+ 6.9	Rüm.2, 1269. Par.3059. Mün.1,946; 2.561

* The declinations of this star come as follows:

Weisse,	+11° 35′ 16″.9
Mün. 1,	34 40 .6
Mün. 2,	35 .8

The position in Mün. 2 is marked very doubtful, and has been rejected. Weisse was corrected —30″, and the mean of this and Mün. 1 adopted. The star will be observed with the meridian circle as soon as practicable.

June 18. Comet very faint. Observation poor.

NEW ASTRONOMICAL WORK.

Cordoba Durchmusterung.— Brightness and Position of Every Fixed Star, down to the Tenth Magnitude, between 22° and 32° of South Declination. JOHN M. THOME, *Director.*

This valuable work, already long announced, contains the first part of the undertaking begun by Dr. THOME, in 1885, on taking charge of the Argentine National Observatory; namely, the continuation of SCHÖNFELD's *Durchmusterung* southward. This has now been accomplished for the region comprised between the parallel of 22°, SCHÖNFELD's lower limit, and that of 42°; and the present volume contains the results for the northern half of the region. The publication of the other half, together with the Atlas, of twelve maps, is promised for the coming year.

In this volume, numbered XVI of the Results of the Argentine National Observatory, are given the positions and magnitudes of 179800 stars; and the second instalment forming vol. XVII, will contain 160580 stars. All the observations, including those of revision, were made by Dr. THOME and Mr. RICHARD H. TUCKER, Jr., the two observing chiefly in alternate zones of one hour each.

The arrangement of the publication is essentially the same as that of ARGELANDER's original work for the northern hemisphere; but the positions are referred to the mean equinox of 1875.0, adopted for all the Cordoba Results, thus far. A comparison of the scale of magnitudes is highly satisfactory. In the first twelve hours of the degree 22°, SCHÖNFELD's magnitudes, assorted by tenths of a unit, show for only two groups below $7^{M}.1$ a mean value differing from that of this catalogue by more than 0.11. Of the thirty-one groups from $7^{M}.0$ to $10^{M}.0$, inclusive, the difference is negative in five and positive in twenty-six; and for the mean of all it amounts to only 0.032, by which amount the Bonn estimates are fainter. A series of 2653 comparisons of the magnitudes with those contained in five hours of the Cordoba Zones gives a result naturally not so accordant, but generally satisfactory. The estimates in the zones are for the most part fainter; yet the mean difference for the total of the groups down to 9^{M}, inclusive, is but 0.034. For stars below this limit, the difference is more pronounced.

The probable error of the positions is given by Dr. THOME as $\pm 0^{s}.42$, $\pm 0'.23$.

It cannot fail to attract attention how greatly the lowering of the limit of magnitude in this work has added to the number of stars. The average number of stars observed in a square degree is given as 56.1, where as the corresponding number in the Northern *Durchmusterung* is 15.2 and in SCHÖNFELD's, 18.5.

A long list of stars is appended for which discordances in the estimates of magnitude suggest the possibility of actual variation.

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NEW ASTRONOMICAL WORK.
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SECOND CATALOGUE OF VARIABLE STARS.

By S. C. CHANDLER.

The unexpected delay in the appearance of this Catalogue has largely been due to the labor involved in carrying out the design of making the elements of every star definitive, in the sense that every observation available up to date should be included in the calculation. This design has been adhered to as faithfully as possible, and the elements here given may be regarded as a practically complete representation of our present knowledge. Even in the few cases, especially mentioned in the notes, where observations of maxima and minima have come to hand since the computation of the elements, they have been compared with the latter, in order to assure that the deviations are merely nominal.

While the general form of the First Catalogue has been retained, some changes have been made to increase its convenience in use, and to supply additional information of value to observers. The nature of these changes will be apparent in the following description of the construction.

Number. The number in the first column of both right and left-hand pages is assigned upon the system of ordinal notation introduced in the First Catalogue, by taking one-tenth of the right-ascension, expressed in time-seconds, for the equinox 1900.0. This precept has not been rigorously applied, nor in the future need be so applied, where two or more variables occur within a few seconds of right-ascension. Also, in the numbers for the newer stars, it has been thought best to violate the strict rule in a few cases, where the numbering would otherwise have been consecutive, in order to provide gaps for future variables. It is essential that numbers once assigned should not be disturbed, even at the expense of deviating by one or two units from the strict enumeration.

Star. The letters according to Argelander's system of nomenclature, extended by the use of double letters, require no special remark.

R.A. and Decl. for 1900.0. These are given to the nearest second and tenth of a minute, respectively. To secure strict accuracy in the last place, all the available meridian and micrometric determinations of position have been collected and reduced accurately to 1875.0, with precessions and secular variations calculated for this epoch. Any appreciable proper motions were then detected and assigned; and the mean places carried forward accurately to the equinox and epoch of 1900.0. For some of the newly discovered variables no precise places could be found, and for these it was necessary to employ the rude data given by the observers — often expressed merely to the tenth of a minute in R.A. and round minute in Declination. It is desirable to suggest that the use of such coarse units is insufficient for the purpose of certainly distinguishing these objects, in their fainter stages, from the small telescopic stars in their vicinity; and that those who are addicted to this habit should raise their standard of precision.

Annual Variations for 1900. Precessions *plus* proper motions for this date, to the nearest hundredth in seconds and minutes, respectively, in R.A. and Declination.

R.A. and Decl. for 1855.0. These are repeated from the First Catalogue, as a matter of general obvious convenience.

Redness. This is expressed in a numerical arbitrary scale, which may be approximately defined as follows: 0 corresponds to white; 1, to the slightest perceptible admixture of yellow with the white; 2, to yellow; 3, to yellowish orange; 4, to full orange or orange-red; 5-10, to increasing shades of intensity up to the deepest red of which we have cognizance in the heavens, exemplified nearly by such stars as 1771 *R Leporis*, 7428 *V Cygni*, 7779 *S Cephei* and 7803 *μ Cephei*. For a fuller description, with details of the determinations, reference is made to *A.J.* VIII, 137, and to the introduction to the First Catalogue. Mr. Yendell has furnished some estimates of stars not included in my determinations, conforming to the same scale; and these are indicated by an asterisk. Where a round unit merely is given, it signifies that it is not the result of direct estimate, made uniformly with the general series, but merely a rude attempt to assign a value from general knowledge, or description by other observers.

Maximum and Minimum Magnitude. These columns contain the previously observed extremes of brightness at each of these phases, derived from a comparative scrutiny of all the trustworthy data up to date, expressed in the prevailing scale of magnitude, namely, that of the *Uranometria Nova*, the *Durchmusterung*, the *Uranometria Argentina* and the Southern *Durchmusterung*. For the fainter magnitudes, where our knowledge of absolute standards for the extension of Argelander's scale downwards is vague, the scale used may be defined by the limits of visibility established by Schönfeld for the Mannheim refactor, 12.7; by my 6¼-inch, 13.0; and by Townley for the Madison 15-inch, 14.7.

M — m. The interval in days and fractions thereof, from minimum to the next following maximum. In the First Catalogue this information was given by the calendar date. The present mode is chosen for economy of space, and is quite as convenient in computing times of minimum from the elements of maximum.

Elements of Maximum. These are uniformly in Greenwich mean time. The principal epoch is expressed in two ways; first, by the ordinary calendar date, without fractions of a day; next by the corresponding Julian date, with the fractions. For the 10 stars of the *Algol*-type, and for 2213 *η Geminorum* and 3186 *T Cancri*, the nature of the light-curves permits the minimum alone to be determined, and therefore the column contains for these stars, as well as for *β Lyrae*, the principal minimum-epoch.

The period is expressed in days and decimal fractions, except for some of the stars of short period, where hours, minutes and seconds are used, following custom, and convenience in writing the small inequalities which it would be awkward to express in decimals of a day.

The factor E is the number of periods elapsed since the principal epoch. The principal epoch is generally the first recorded maximum (or minimum) after discovery, in conformity with the practice of Argelander and Schönfeld. Wherever this rule is departed from, it is for the purpose of adhering to the enumeration already established in standard investigations of particular stars. Exceptional deviations from these rules are recorded in the notes.

Following the periods are the numerical inequalities depending on powers or periodic functions of E. In addition to the cases where these inequalities have been numerically determined, there are a large number of others where the existence of such terms has been discovered, but in which it is not yet practicable to determine the coefficients. These are indicated in the column of remarks by the words "periodic inequality," a query being affixed when the evidence is somewhat obscure.

The column of remarks also contains, for the non-periodic stars, a characterization of the type of variability. For want of a better concise phrase, the term "Irregularly periodic" is used for stars in which the periodicity is manifested in a slight degree. The term "Irregular" is used where there is an entire absence of any discernible law in the changes of brightness.

It is hardly necessary to say that the elements are the result of original investigation in all cases except where the authority is accredited in the remarks.

Basis of Elements. These columns contain the number of maxima, M, the number of minima, m, and the interval embraced by them, upon which the calculation of the elements depends. This information is of the utmost importance and usefulness to future observers of these objects, indicating the character of our present information, and guiding the selection of stars for observation. It should be noted that a very large proportion of the maxima and minima were determined by two or more observers, so that the actual number of observations of the phases used in the calculations is much larger than appears.

For convenience in computing ephemerides, and in comparing future observations with the elements of the Catalogue, a table is added for the conversions of Julian and Calendar dates during the next ten years.

TABLE FOR CONVERTING JULIAN AND CALENDAR DATES.

	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903
Jan. 1	241 2465	2830	3195	3560	3926	4291	4656	5021	5386	5751	6116
Feb. 1	2496	2861	3226	3591	3957	4322	4687	5052	5417	5782	6147
Mar. 1	2524	2889	3254	3620	3985	4350	4715	5080	5445	5810	6175
Apr. 1	2555	2920	3285	3651	4016	4381	4746	5111	5476	5841	6206
May 1	2585	2950	3315	3681	4046	4411	4776	5141	5506	5871	6236
June 1	2616	2981	3346	3712	4077	4442	4807	5172	5537	5902	6267
July 1	2646	3011	3376	3742	4107	4472	4837	5202	5567	5932	6297
Aug. 1	2677	3042	3407	3773	4138	4503	4868	5233	5598	5963	6328
Sept. 1	2708	3073	3438	3804	4169	4534	4899	5264	5629	5994	6359
Oct. 1	2738	3103	3468	3834	4199	4564	4929	5294	5659	6024	6389
Nov. 1	2765	3134	3499	3865	4230	4595	4960	5325	5690	6055	6420
Dec. 1	241 2799	3164	3529	3895	4260	4625	4990	5355	5720	6085	6450

In view of the profuse announcements of variability during the past few years, the very moderate increase in the present Catalogue over the previous one may excite surprise among those who do not know the facility with which rubbish collects about the subject. This Catalogue would be very much longer if all such announcements, made on what might be regarded as reputable authority, had been admitted. But it would have ceased thereby to represent any exact knowledge. Among those who busy themselves with the subject there are some with whom the uncritical habits of the seventeenth century still prevail, and who emulate the exuberant enthusiasm of Montanari, who discovered more than a hundred new variables — only one of which is now in our lists — and who made no observations of any service whatever, as to the phenomena; rather than the critical and conscientious care of Argelander, who first winnowed the chaff from the wheat, in his little catalogue of 18 stars published in 1844, and from that point elevated the subject into a science; or of Schönfeld, who extended it and maintained its purity.

No apology therefore is needed for the unrelaxed application of the principles, for deciding the delicate and perplexing question as to what stars shall be admitted, which were set forth in the introduction to the First Catalogue. They may be summed up in two sentences. It is a paramount consideration that our knowledge must be kept clear of confusion, even at the risk of an incomplete statement of it. No star should be inserted, no matter how high the authority on which its variability is declared, without independent verification on undoubted authority and evidence. Otherwise the result will be chaos.

As a matter of fact then, the only stars added are those which have been sufficiently confirmed since the first edition. On the other hand, four stars which have long appeared in the older lists have been dropped, for reasons which will be stated in the notes to the supplementary list, to which they have been relegated; and there are perhaps two or three others which might be treated in the same way. During the past two years other investigations have prevented my giving the attention which I had previously given, to the observation of the long list of objects awaiting confirmation; but Mr. Yendell has taken the matter into efficient charge, and has kept more than a hundred of them on his working list. It is to his discrimination and zeal that many of the confirmations are due, as will be seen in the notes to the catalogue. He has kindly kept me supplied with the evidence on this matter afforded by his observations. I am also deeply indebted to Mr. Parkhurst and Mr. Yendell for the results of their very numerous observations, in advance of publication, of maxima and minima of known variables. During the last few months I have been in continual correspondence with these gentlemen, and to them is almost entirely due the completeness with which the present work has been brought up to date. Without their cordial collaboration and interest, indeed, it would have been extremely imperfect. Profound acknowledgements are also gratefully made to Messrs. Townley, Roberts and Sawyer, for manuscript copies of observations, and other information of the greatest value.

The work of accurate observation of the phenomena of the known variables, in which these astronomers have been so assiduous — and which, as in the case of the comets, is of a much higher grade than the discovery of new objects — is the most essential element to the progress of this branch of astronomy, and is a field which affords ample room for many more participants.

This seems as appropriate a place as any for an important remark. In comparing future observations of maxima and minima with the elements of the catalogue, it should be borne in mind that the periods here given are their mean values, determined generally from long series of observations, and that any deviations, apparently larger than the accidental error of observation, are probably due to some systematic inequality in the course of development. It will be seen from an inspection of the Catalogue that, beside the forty cases among the variables of long periods for which I have determined such terms numerically, there are about thirty others where their existence is distinctly indicated. Indeed, as I have elsewhere stated, there is scarcely a case, where the observations are sufficiently continuous to give evidence on the point, in which they are not manifest; and we may safely conclude that they are generally prevalent, and inseparably associated with this type of variability. They are in general periodic, running through cycles of fifty or sixty periods on the average, sometimes of only twenty or thirty periods. The amplitude is sometimes considerable, rising to, say, a fifth of the star's period. For the most part, however, they are comprised within the limits of twenty or thirty days from the time of the phase indicated by the mean period. In the preparation of ephemerides for the use of observers, in preparing to observe the phases, it therefore does not seem advisable to apply arbitrary corrections, dependent on one or two recently observed maxima, as is sometimes done: on account of the risk of thereby influencing prejudicially the intending observer's results, which ought to be free of all bias. It seems better that his work should be done under the influence only of the general warning that such real variations from the predicted times are continually in operation, by the very nature of the phenomena. There is no class of work in which freedom from preoccupation of mind is so essential as in this. This is so especially true of the stars of the *Algol*-type that the publication of ephemerides of their minima nearer than to the nearest hour, is to be deprecated.

The above remarks of course do not apply to stars which have been recently discovered, or which have been rather infrequently observed. The uncertainty in the elements given for these will be apparent by inspection of the column "Basis of Elements," or is especially remarked in the notes at the end of the Catalogue.

Special effort has been made to supply as many epochs of minimum in the present Catalogue as the data available permitted; this being the particular in which our knowledge is most defective. From column $M - m$ it will be seen that this element is given in 115 cases, as against only 63 in the First Catalogue.

No.	Star	1900.0		1900 Annual Variation		1855.0		Redness	Magnitude	
		R.A.	Decl.			R.A.	Decl.		Max.	Min.
		h m s	° '	s	'	h m s	° '			
100	T Ceti	0 16 42	—20 36.7	+3.04	+0.33	0 14 26	—20 51.8	4	5.1– 5.3	6.4– 7.0
107	T Cassiopeae	17 49	+55 14.3	3.22	0.33	15 25	+54 59.3	7.3	7.0– 8.0	11.0–11.2
112	R Andromedae	18 45	+38 1.4	3.16	0.33	16 25	+37 46.1	5.0	5.6– 8.6	<12.8
114	S Ceti	18 58	— 9 53.0	3.05	0.33	16 11	—10 7.9	2.0	7.0– 8.0	12
116	B Cassiopeae	19 15	+63 35.5	3.30	0.33	16 47	+63 20.6	–	>1	?
161	T Piscium	26 49	+14 2.9	3.11	0.33	24 29	+13 48.0	0	9.5–10.2	10.5–11.0
209	α Cassiopeae	34 50	+55 59.3	3.38	0.33	32 18	+55 44.5	5	2.2	2.8
224	S Andromedae	37 15	+40 43.2	3.26	0.33	34 49	+40 28.3	5	7	0?
243	U Cassiopeae	40 46	+47 42.6	3.33	0.33	38 16	+47 27.8	6	8.0– 8.8	<15
320	U Cephei	0 53 23	+81 20.2	5.09	0.33	0 49 38	+81 5.5	0	7.1	9.2
432	S Cassiopeae	1 12 18	+72 5.1	4.35	0.32	1 9 4	+71 50.8	6.7	6.7– 8.6	<13.5
434	S Piscium	12 21	+ 8 24.3	3.13	0.32	10 0	+ 8 9.9	1.0	8.2– 9.3	<14.7
466	U Piscium	17 41	+12 20.7	3.17	0.32	15 18	+12 6.4	–	9.5	14.5–15.0
494	R Sculptoris	22 22	—33 3.5	2.77	0.31	20 17	—33 17.8	9	5.7	7.6– 8.0
513	R Piscium	25 29	+ 2 21.9	3.09	0.31	23 10	+ 2 7.9	2.0	7 – 8.8	<13
678	U Persei	52 56	+54 20.1	3.95	0.29	50 0	+54 7.0	6.4*	8.2	<11
715	S Arietis	1 59 16	+12 2.8	3.21	0.29	1 56 51	+11 49.7	2	9.1– 9.8	14?
782	R Arietis	2 10 25	+24 35.5	3.40	0.28	2 7 53	+24 22.8	1.8	7.6– 9.0	11.7–13.0
793	T Persei	12 12	+58 29.5	4.26	0.28	9 0	+58 16.7	4	8.2	9.3
806	o Ceti	14 18	— 3 25.7	3.03	0.27	12 1	— 3 38.3	5.9	1.7– 5.0	8 – 9.5
814	S Persei	15 41	+58 7.8	4.27	0.28	12 29	+57 55.2	5.0	8.5	13
845	R Ceti	20 55	— 0 37.8	3.06	0.27	18 38	— 0 50.1	2.4	7.5– 8.8	13.5
893	U Ceti	28 56	—13 35.2	2.88	0.27	26 45	—13 47.2	3	6.8– 7.3	10.5<
906	R Trianguli	30 59	+33 49.8	3.62	0.26	28 16	+33 37.8	5.4*	5.8	11.7
976	T Arietis	42 45	+17 5.5	3.34	0.25	40 15	+16 54.1	3.2	7.9– 8.6	9.3– 9.7
1072	ρ Persei	2 58 46	+38 27.2	3.83	0.24	55 54	+38 16.5	2	3.4	4.2
1090	β Persei	3 1 40	+40 34.2	3.89	0.23	2 58 45	+40 23.6	0	2.3	3.5
1113	U Arietis	5 30	+14 24	3.32	0.23	3 3 1	+14 14.0	–	7.8	<11
1222	R Persei	23 41	+35 19.6	3.81	0.21	20 50	+35 10.1	2.3	7.7– 9.2	12.8–13.5
1367	X Tauri	47 50	+ 7 28.8	3.22	0.18	45 26	+ 7 20.6	. .	6.6	8.1
1411	λ Tauri	3 55 8	+12 12.5	3.32	0.17	3 52 39	+12 4.6	0	3.4	4.2
1537	T Tauri	4 16 10	+19 17.8	3.49	0.15	4 13 33	+19 11.3	0	9.2–11.5	12.8–<13.5
1574	W Tauri	22 16	+15 53	3.42	0.14	19 43	+15 46.5	5	9?	<12.5
1577	R Tauri	22 49	+ 9 56.4	3.29	0.14	20 21	+ 9 50.1	4.5	7.4– 9.0	12.8–13.5
1582	S Tauri	23 43	+ 9 43.5	3.28	0.14	21 16	+ 9 37.3	2.5	9.5–10.0	<13.5
1623	T Camelopardalis	30 26	+65 59	5.85	0.13	26 4	+65 53	6*	7.9– 8.2	<12
1635	R Reticuli	32 30	—63 14.2	0.61	0.12	32 3	—63 19.8	–	7	<13
1654	R Doradus	35 36	—62 16.4	0.70	0.12	35 5	—62 21.8	7	5.7	6.7
1717	V Tauri	46 15	+17 22.1	3.47	0.11	43 39	+17 17.4	3.3	8.3– 9.0	<13.5
1761	R Orionis	53 35	+ 7 58.7	3.25	0.10	51 8	+ 7 54.3	4.9	8.7– 9.1	11.2–13.5
1768	ε Aurigae	54 47	+43 40.5	4.30	0.09	51 34	+43 36.2	1	3.0	4.5
1771	R Leporis	4 55 3	—14 57.4	2.73	0.09	4 53 0	—15 1.7	9.4	6 – 7	8.5?
1855	R Aurigae	5 9 13	+53 28.4	4.83	0.07	5 5 36	+53 25.0	6.5	6.5– 7.8	12.5–12.7
1923	S Aurigae	20 31	+34 3.7	3.96	0.06	17 33	+34 2.1	6.7	9.4–11.0	<14.5
1944	S Orionis	24 5	— 4 46.4	2.96	0.05	21 51	— 4 48.7	6.4	8.3– 9.5	11.0–13.0
1953	T Aurigae	25 34	+30 22.2	3.85	0.05	22 41	+30 19.9	–	4.5	<15
1981	S Camelopardalis	30 13	+68 44.6	6.48	0.04	25 22	+68 42.5	7.8*	8.5	12
1986	T Orionis	30 56	— 5 32.4	2.94	0.04	28 43	— 5 34.5	0	9.7	13
2013	U Aurigae	35 32	+31 59	3.90	0.04	32 37	+31 57	7.5*	8.6	12
2098	α Orionis	49 45	+ 7 23.3	3.25	0.02	47 19	+ 7 22.9	6	1	1.4
2100	U Orionis	5 49 53	+20 9.5	3.56	+0.01	5 47 13	+20 8.7	7	6.4– 7.5	<12
2213	η Geminorum	6 8 51	+22 32.2	+3.62	—0.01	6 6 8	+22 32.6	3	3.2	3.7– 4.2

No.	M—m	Elements of Maximum, Greenwich M.T. Epoch (Cal.)	(Julian)	Period	Inequalities	Remarks	Basis of Elements M	m	Dates included
	d		d	d					
100	–	. . . .		. . . .		Irregularly periodic?	–	–	
107	221	1871 Mar. 31	=240 4515	+445.0 E		Periodic inequality	13	5	1842, 57, 71–91
112	170 : :	1859 Mar. 27	240 0131	+410.7 E	+25 sin(12° E+90°)		21	1	1827, 55–93
114	145	1872 Dec. 27	240 5155	+321.0 E			7	3	1872–91
116	–	. . . .		. . . .		New star of 1572	–	–	
161	–	. . . .		. . . .		Irregular	–	–	
209	–	. . . .		. . . .		Irregular	–	–	
224	–	. . . .		. . . .		New star of 1885 in *Androm.* neb.	–	–	
243	120	1886 Dec. 12	241 0253	+276.0 E			7	2	1856, 57, 86–92
320	–	Min. 1880 June $23^d\,9^h\,28^m.0$		$+2^d\,11^h\,49^m\,38^s.25$E	$+95^m$ sin(0°.08E+283°)		–	50	1828, 80–93
432	300 : :	1863 Mar. 18	240 1583	+610.5 E	+50 sin(10°E+50°)		14	2	1843, 63–93
434	200 :	1866 Jan. 4	240 2606	+405.3 E		Periodic inequality	10	1	1855–85, 92
466	83	1880 Jan. 8	240 7723	+172.7 E		Periodic inequality	12	11	1879–92
494	131 :	1872 Dec. 11	240 5139	+207.5 E			4	3	1872–91
513	149	1866 Nov. 22	240 2928.0	+344.15 E	+13 sin(12°E+180°)		14	2	1850, 55, 65–91
678	–	. . . .		. . . .			–	–	
715	165 :	1872 Mar. 22	240 4867	+292.2 E		Periodic inequality	9	1	1848–86, 92
782	91.5	1866 Sept. 4	240 2849.0	+186.60 E	+7 sin(5°E+235°)		43	21	1828–46, 58–92
793	–	. . . .		. . . .		Irregularly periodic?	–	–	
806	112.0	1866 Dec. 27	240 2963.4	+331.60 E	+25 sin(4°.5E+90°)+*		105	15	1596–1892
814	–	. . . .		. . . .		Irregularly periodic?	–	–	
845	70	1867 Mar. 2	240 3028.0	+167.0 E		Periodic inequality	20	3	1794, 1841–93
893	–	1884 Dec. 11	240 9522	+235.8 E			8	–	1877, 81–90
906	119	1890 Sept. 30	241 1641	+262 E			5	3	1856, 87–92
976	127	1873 Mar. 31	240 5249	+313 E			10	9	1871–74, 84–92
1072	–	. . . .		. . . .		Irregularly periodic	–	–	
1090	–	Min. 1888 Jan. $3^d\,7^h\,21^m\,29^s.23$		$+2^d\,20^h\,48^m\,55.425$E	+†		–	496	1782–1887
1113	–	. . . .		. . . .			–	–	
1222	96	1861 Sept. 25	240 1044.0	+210.1 E	+20 sin(7°.5 E+135°)		31	3	1833, 61–92
1367	–	. . . .		. . . .			–	–	
1411	–	Min. 1887 Dec. $6^d\,11^h\,57^m.0$		$+3^d\,22^h\,52^m\,12^s.0$E		*Algol*-type. Per. ineq.	–	53	1796, 1844–92
1537	–	. . . .		. . . .		Irregular	–	–	
1574	78	1880 Feb. 15	240 7761	+141 E		Parkhurst's elements	4	2	1880, 87–93
1577	140 :	1862 May 1	240 1262	+325 E			21	2	1798, 1855–92
1582	70 :	1860 Feb. 14	240 0455.5	+375.5 E			10	1	1855–59, 83–93
1623	–	1891 Dec. 24	241 2091	+370 E		Elements uncertain	2	–	1891, 92
1635	–	1864 Feb. 5	240 1907	+280 E			5	–	1864–67, 91, 92
1654	–	. . . .		. . . .			–	–	
1717	89	1872 Sept. 14	240 5051.0	+170.4 E		Periodic inequality?	18	6	1826, 54, 71–93
1761	214 :	1855 Mar. 23	239 8666	+380.0 E			12	1	1846–74, 83–92
1768	–	. . . .		. . . .		Irregular	–	–	
1771	212	1864 Mar. 5	240 1936.7	+436.1 E		Periodic inequality	19	13	1855–83
1855	241	1862 Nov. 16	240 1461.8	+460.6 E			17	6	1862–91
1923	–	. . . .		. . . .		Irregularly periodic	–	–	
1944	194	1870 Feb. 1	240 4095	+412 E			6	11	1863–92
1953	–	. . . .		. . . .		New star of 1892	–	–	
1981	–	1892 Aug. 22	241 2333	+111 E		Elements very uncertain	3	–	1892, 3
1986	–	. . . .		. . . .		Irregular	–	–	
2013	–	1891 Jan. 31	241 1764	+397 E		Elements very uncertain	2	–	1891, 93
2098	–	. . . .		. . . .		Irregularly periodic	–	–	
2100	145 :	1885 Dec. 7	=240 9883	+371 E		Periodic inequality	8	1	1885–93
2213	–	Min. 1865 Nov. 5		+231.4 E		Periodic inequality	–	14	1844, 65–81

* +25 sin(1°.125 E+188°.2)   † $+173^m.3$ sin($\frac{1}{50}$ E+202°.5) $+18^m.0$ sin($\frac{3}{40}$ E +203°.25). See notes.

No.	Star	1900.0		1900 Annual Variation		1855.0		Redness	Magnitude	
		R.A.	Decl.			R.A.	Decl.		Max.	Min.
		h m s	° '	s	'	h m s	° '			
2258	V Aurigae	6 16 18	+47 42.5	+4.54	—0.02	6 12 54	+47 43.5	–	8.5– 10	<11.5
2266	V Monocerotis	17 41	— 2 8.7	3.02	0.03	15 25	— 2 7.6	3.4	6.9	10.7<
2279	T Monocerotis	19 49	+ 7 8.4	3.24	0.03	17 24	+ 7 9.7	2	5.8– 6.4	7.4– 8.2
2362	R Monocerotis	33 42	+ 8 49.3	3.28	0.05	31 15	+ 8 51.7	0	9.5	13
2375	S Monocerotis	35 28	+ 9 59.3	3.31	0.05	33 0	+10 1.5	2	4.9	5.4
2478	R Lyncis	53 3	+55 28.1	4.96	0.08	49 20	+55 31.6	4.8	7.8– 8.0	<13
2509	ζ Geminorum	6 58 11	+20 43.0	3.56	0.09	55 30	+20 46.7	2	3.7	4.5
2528	R Geminorum	7 1 20	+22 51.5	3.62	0.09	6 58 37	+22 55.4	5.7	6.6– 7.8	<13.5
2539	R Canis minoris	3 13	+10 10.9	3.30	0.09	7 0 44	+10 14.9	5.5	7.2– 7.9	9.5–10.0
2583	L_2 Puppis	10 29	—44 28.8	1.82	0.10	9 7	—44 24.2	8	3.5	6.3
2610	R Canis Majoris	14 56	—16 12.4	2.70	0.11	12 55	—16 7.6	0	5.9	6.7
2625	V Geminorum	17 34	+13 17.0	3.37	0.11	15 2	+13 21.9	2.8	8.2– 9.1	12.0–14.0
2676	U Monocerotis	26 1	— 9 34.0	2.86	0.12	23 53	— 9 28.6	3	5.9– 7.3	6.6– 8.0
2684	S Canis minoris	27 18	+ 8 31.9	3.26	0.12	24 51	+ 8 37.4	4.1	7.2– 8.0	10.5–12.7
2691	T Canis minoris	28 26	+11 57.5	3.34	0.12	25 56	+12 3.0	2	9.0– 9.7	<13.5
2735	U Canis minoris	35 55	+ 8 36.8	3.26	0.14	33 28	+ 8 42.2	5.1	8.5– 9.0	12.3–13.5
2742	S Geminorum	37 3	+23 41.1	3.61	0.14	34 20	+23 47.2	3	8.2– 8.7	<13.5
2780	T Geminorum	43 18	+23 59.0	3.61	0.15	40 36	+24 5.5	3.0	8.1– 8.7	<13.5
2783	S Puppis	43 50	—47 51.9	1.74	0.15	42 31	—47 45.4	–	7.2	9
2815	U Geminorum	49 10	+22 15.8	3.56	0.15	46 30	+22 22.7	0.0	8.9– 9.7	13.1
2852	V Puppis	55 22	—48 58.4	1.73	0.16	54 4	—48 51.2	–	4.4	5.2
2857	U Puppis	7 56 8	—12 33.8	2.81	0.16	7 54 2	—12 26.6	3.2	8.5– 9.0	<14
2946	R Cancri	8 11 3	+12 2.0	3.32	0.18	8 8 34	+12 10.1	5.3	6.0– 8.3	<11.7
2976	V Cancri	16 1	+17 36.1	3.43	0.19	13 27	+17 44.5	4.3	6.8– 7.7	<12
3060	U Cancri	30 3	+19 14.4	3.44	0.20	27 28	+19 23.5	2.3	8.4–10.6	<14
3109	S Cancri	38 14	+19 23.6	3.44	0.21	35 39	+19 33.2	1	8.2	9.8
3128	R Pyxidis	41 17	—27 50.2	2.53	0.22	39 23	—27 40.5	6	8.5	<11
3170	S Hydrae	48 21	+ 3 26.7	3.13	0.22	46 0	+ 3 36.8	2.1	7.5– 8.7	<12.2
3184	T Hydrae	50 48	— 8 45.6	2.92	0.23	48 37	— 8 35.4	1.8	7.0– 8.1	<13
3186	T Cancri	8 50 57	+20 13.9	3.43	0.23	8 48 23	+20 24.1	7.4	8.0– 8.5	9.3–10.5
3407	S Antliae	9 27 56	—28 11.2	2.63	0.26	9 25 27	—27 59.4	0	6.7	7.3
3409	N Velorum	28 11	—56 35.6	1.83	0.26	26 49	—56 23.8	2	3.4	4.4
3418	R Carinae	29 44	—62 20.8	1.52	0.26	28 36	—62 8.9	5	4.3– 5.7	9.3–10.0
3477	R Leonis minoris	39 35	+34 58.3	3.61	0.27	36 52	+35 10.6	6.0	6.1– 7.8	13
3493	R Leonis	42 11	+11 53.6	3.23	0.28	39 45	+12 5.9	6.9	5.2– 6.7	9.4–10.0
3495	*l* Carinae	42 30	—62 2.8	1.65	0.28	41 16	—61 50.4	–	3.7	5.2
3567	V Leonis	9 54 28	+21 44.5	3.36	0.29	9 51 57	+21 57.3	1.7	8.6	<13.5
3633	R Antliae	10 5 27	—37 14.4	2.59	0.29	10 3 30	—37 1.2	–	6.5	<8
3637	S Carinae	6 11	—61 3.6	1.92	0.29	4 45	—60 50.4	5	6.0	9.0– 9.2
3712	U Leonis	18 42	+14 30.6	3.22	0.30	16 17	+14 44.1	–	9.5	<13.5
3796	U Hydrae	32 37	—12 51.9	2.96	0.31	30 24	—12 38.1	7	4.5	6.1–6.3
3825	R Ursae Majoris	37 34	+69 18.0	4.32	0.31	34 19	+69 32.1	1.6	6.0– 8.2	13.2
3847	η Carinae	41 11	—59 9.5	2.32	0.31	39 27	—58 55.4	5	>1	7.4
3881	V Hydrae	46 46	—20 43.2	2.91	0.32	44 34	—20 28.8	9	6.7	9.5
3890	W Leonis	48 21	+14 14.9	3.18	0.32	45 58	+14 29.2	3.5*	9	<14
3908	T Carinae	51 18	—59 54.2	2.39	0.32	49 30	—59 44.8	–	6.2	6.9
3934	R Cratèris	10 55 38	—17 47.3	2.95	0.32	10 53 26	—17 32.8	8.1	>8	<9
3994	S Leonis	11 5 41	+ 6 0.2	3.11	0.32	11 3 21	+ 6 14.9	0.0	9.0–10.0	<13
4160	T Leonis	33 19	+ 3 55.5	3.08	0.33	31 0	+ 4 10.5	–	10?	<13.5
4300	X Virginis	56 44	+ 9 37.7	3.08	0.33	54 25	+ 9 52.7	–	8–10	12
4315	R Comae	11 59 7	+19 20.3	3.08	0.33	11 56 49	+19 35.4	4.0	7.4– 8.0	<13.5
4377	T Virginis	12 9 29	— 5 28.8	+3.08	—0.33	12 7 10	— 5 13.8	4.1	8.0– 8.8	10–<13.5

No.	$M-m$	Elements of Maximum, Greenwich M.T.					Basis of Elements		
		Epoch (Cal.)	(Julian)	Period	Inequalities	Remarks	M	m	Dates included
2258	–	1886 Dec. 9	=241 0250^d	+315^d E		Elements very uncertain	3	–	1886, 91, 92
2266	–	1883 Feb. 14	240 8843	+333.5 E			6	–	1853, 83–93
2279	7.93	1885 Apr. 1	240 9633.81	+ 27.0037 E			–	–	
2362	–	. . . . . .	. . . . .	. . .		Irregular	–	–	
2375	1.84	1870 Jan. 31	240 4094.83	+ 3.44305		Winnecke's elements; doubtful	–	–	
2478	143 :	1874 Sept. 15	240 5782	+380.0 E			8	1	1874, 84–92
2509	5.015	1888 Jan. 3	241 0640.603	+ 10.15382 E		See notes	–	–	
2528	121	1868 Feb. 24	240 3387.0	+370.2 E		Periodic inequality	20	7	1796, 1855–92
2539	135	1859 Feb. 28	240 0104.5	+336.5 E		Periodic inequality	15	2	1859–74, 83–93
2583	60	1872 Mar. 28	240 4881.0	+136.50 E			6	2	1872–74, 86, 91
2610	–	Min. 1887 Mar. $26^d\ 15^h\ 18^m$		$+1^d\ 3^h\ 15^m\ 46^s.0$ E		*Algol*-type	–	23	1887–93
2625	134	1880 Feb. 1	240 7747	+277.0 E			10	2	1857, 80–92
2676	18.0	1873 Apr. 19	240 5268	+ 45.20 E		See notes	–	–	
2684	164	1863 May 3	240 1629	+330.3 E	+20 sin(12°E+30°)		16	2	1856–92
2691	–	1870 Mar. 16	240 4138	+322.7 E		Periodic inequality?	9	–	1854, 70–93
2735	175	1880 Feb. 14	240 7760	+410 E			6	6	1880–93
2742	127 :	1852 Feb. 27	239 7546	+294 E			18	1	1848–73, 86–93
2780	–	1848 Dec. 7	239 6369.5	+288.1 E			16	–	1848–74, 86–93
2783	–	. . . . . .	. . . . .	. . . .			–	–	
2815	–	1892 Dec. 15	241 2448	+ 86.3 E		Irregularly periodic	–	–	
2852	–	. . . . . .	. . . . .	. . . .			–	–	
2857	–	1881 Mar. 8	240 8148	+315 E			5	–	1881–83, 93
2946	125 : :	1852 Apr. 21	239 7600.1	+352.81 E	$+0.207\,E^2$		18	–	1830, 52–85
2976	102 :	1871 May 20	240 4568	+271.9 E			10	1	1871–89
3060	–	1853 Apr. 6	239 7950	+307.5 E	$-0.06\,E^2$		14	–	1853–59, 69–93
3109	–	Min. 1867 Aug. $31^d\ 14^h\ 2^m.89$		$+9^d\ 11^h\ 37^m\ 45^s$ E		Schönfeld's el. *Algol*-type	–	–	
3128	–	. . . . . .	. . . . .	. . . .			–	–	
3170	–	1857 Feb. 13	239 9359	+257.0 E		Periodic inequality	16	–	1852–86
3184	–	1858 Feb. 23	239 9734.5	+289.4 E		Schönfeld's elements	18	–	1851–73, 84, 92
3186	–	Min. 1858 Jan. 26	239 9706	+482 E			–	9	1858–75, 84, 87
3407	–	Min. 1888 Apr. $13^d\ 12^h\ 38^m.0$		$+0^d\ 7^h\ 46^m\ 48^s.0$ E		*Algol*-type	–	15+	1888–93
3409	–	. . . . . .	. . . . .	. . . .		Period short	–	–	
3418	153	1871 July 31	240 4640	+311.5 E		Periodic inequality	16	10	1752, 1867–92
3477	170	1865 Mar. 12	240 2308.0	+370.5 E	+20 sin(10° E+300°)		18	3	1796, 1865–87
3493	144	1757 Apr. 21	236 2902.0	+312.90 E	+25 sin(2°.75 E+318°)		46	15	1757–1890
3495	15	1871 July 24	240 4633.0	+35.05 E			24	7	1871–74, 91, 92
3567	–	1882 Apr. 10	240 8546	+274 E		Parkhurst's elements	6	–	1855, 56, 82–91
3633	–	. . . . . .	. . . . .	. . . .			–	–	
3637	86	1872 May 8	240 4922	+148.7 E			4	3	1872–80, 91
3712	–	. . . . . .	. . . . .	. . . .		Variability doubtful	–	–	
3796	–	. . . . . .	. . . . .	. . . .		Irregularly periodic?	–	–	
3825	107	1853 Apr. 7	239 7951.2	+302.1 E	+15 sin(10° E+190°)		38	15	1843–92
3847	–	. . . . . .	. . . . .	. . . .		Irregular	–	–	
3881	–	1873 Mar. 15	240 5233	+575 E		Elements very uncertain	5	3	1873–93
3890	–	1872 Feb. 12	240 4836	+394.3 E		Parkhurst's elements	6	–	1872–91
3908	–	. . . . . .	. . . . .	. . . .			–	–	
3934	–	. . . . . .	. . . . .	. . . .		Variability not certain	–	–	
3994	125 :	1860 Dec. 1	240 0746.0	+190.0 E	+25 sin(10° E+60°)		18	1	1859–93
4160	–	. . . . . .	. . . . .	. . . .		Variability not certain	–	–	
4300	–	. . . . . .	. . . . .	. . .			–	–	
4315	–	1856 Dec. 18	239 9302	+361 E			7	–	1831, 56, 83–91
4377	–	1861 Apr. 26	=240 0891	+339.5 E			8	–	1861–75, 84, 88

No.	Star	1900.0		1900		1855.0		Redness	Magnitude	
		R.A.	Decl.	Annual Variation		R.A.	Decl.		Max.	Min.
		h m s	° ′	s	′	h m s	° ′			
4407	R Corvi	12 14 27	—18 42.0	+3.10	—0.33	12 12 8	—18 26.9	3.7	6.8– 7.7	<11.5
4492	Y Virginis	28 44	— 3 52.3	3.08	0.33	26 25	— 3 37.3	3.6	8 – 9.4	11.5–13
4511	T Ursae Majoris	31 50	+60 2.3	2.75	0.33	29 47	+60 17.2	2.0	6.0– 8.5	12.2–13.0
4521	R Virginis	33 26	+ 7 32.3	3.05	0.33	31 9	+ 7 47.2	1.3	6.5– 8.0	9.7–11.0
4536	R Muscae	35 58	—68 51.5	3.61	0.33	33 17	—68 36.7	–	6.6	7.4
4557	S Ursae Majoris	39 34	+61 38.4	2.63	0.33	37 35	+61 53.3	3.2	6.7– 8.2	10.2–11.5
4596	U Virginis	12 46 1	+ 6 5.8	3.04	0.33	12 43 45	+ 6 20.6	1.1	7.7– 8.1	12.2–12.8
4731	S Canum Venat.	13 8 31	+37 54.5	2.77	0.32	13 6 24	+38 8.9	6.3*	7.3	9
4805	W Virginis	20 52	— 2 51.5	3.09	0.31	18 33	— 2 37.4	0.4	8.7– 9.2	9.8–10.4
4816	V Virginis	22 38	— 2 39.2	3.09	0.31	20 19	— 2 25.2	2.7	8.0– 9.0	<13
4826	R Hydrae	24 15	—22 45.9	3.27	0.31	21 48	—22 31.8	5.9	3.5– 5.5	9.7
4847	S Virginis	27 47	— 6 40.8	3.13	0.31	25 26	— 6 26.8	2.6	5.7– 7.8	12.5
4940	W Hydrae	43 23	—27 52.0	3.38	0.30	40 51	—27 38.5	7	6.7	8.0
4948	R Canum Venat.	44 39	+40 2.4	2.58	0.30	42 43	+40 15.9	–	6.7– 7.0	11.5
5037	RR Virginis	13 59 35	— 8 43.1	3.17	0.29	13 57 12	— 8 30.0	–	>11	<14
5070	Z Virginis	14 4 58	—12 49.8	3.23	0.29	14 2 33	—12 36.5	–	9.5–11	<14
5095	R Centauri	9 22	—59 26.9	4.28	0.28	6 10	—59 14.1	6	6.0– 6.3	8.7– 9.8
5097	T Bootis	9 25	+19 32.0	2.82	0.28	7 18	+19 44.7	–	9.7?	<13
5156	X Bootis	19 27	+16 46.4	2.84	0.27	17 19	+16 58.8	4	9.0– 9.4	10.2
5157	S Bootis	19 32	+54 15.9	+2.01	0.27	18 1	+54 28.3	2.8	7.7– 8.5	12.5–13.2
5190	R Camelopardalis	25 6	+84 17.1	—4.83	0.27	28 54	+84 29.2	2.1	7.2– 8.6	11.8–13.5
5194	V Bootis	25 42	+39 18.5	+2.42	0.27	23 54	+39 30.4	3.6	6.9– 7.3	9.2–10.5
5237	R Bootis	32 47	+27 10.2	2.65	0.26	30 48	+27 22.1	2.7	5.9– 7.8	11.3–12.2
5249	V Librae	34 48	—17 13.6	3.33	0.26	32 18	—17 1.8	–	9.3	12.2
5274	W Bootis	39 2	+26 57.2	2.64	0.26	37 3	+27 8.9	–	5.2	6.1
5319	R Apodis	46 28	—76 15.3	6.70	0.26	41 30	—76 4.0	–	5.5	6.2
5338	U Bootis	49 42	+18 6.0	2.78	0.25	47 37	+18 17.1	2.7	9.1– 9.3	12–13.6
5374	δ Librae	14 55 38	— 8 7.3	3.20	0.24	53 14	— 7 56.4	1	5.0	6.2
5402	T Triang. Austr.	15 0 24	—68 20.1	5.46	0.24	14 56 20	—68 9.4	–	6.9	7.4
5430	T Librae	5 2	—19 38.3	3.42	0.23	15 2 28	—19 27.8	–	9.2–10.2	<14.7
5438	Y Librae	6 24	— 5 38.0	3.17	0.23	4 2	— 5 27.6	–	8.5	?
5465	R Triang. Austr.	10 49	—66 7.7	5.31	0.22	6 52	—65 57.5	–	6.6– 6.8	7.5– 8.0
5484	U Coronae	14 7	+32 0.8	2.45	0.22	12 17	+32 10.8	0.0	7.5	8.9
5494	S Librae	15 39	—20 1.6	3.44	0.22	13 4	—19 51.7	3.0	7.6– 8.3	<13
5501	S Serpentis	16 59	+14 40.4	2.81	0.22	14 52	+14 50.3	4.1	7.6– 8.7	12.5?
5504	S Coronae	17 19	+31 43.6	2.45	0.22	15 29	+31 53.5	4.9	6.1– 7.8	11.9–12.5
5583	X Librae	30 26	—20 50.0	3.48	0.20	27 50	—20 40.8	–	9.5– 9.9	14
5593	W Librae	32 12	—15 50.6	3.37	0.20	29 40	—15 41.5	–	9.8	<14
5617	U Librae	36 13	—20 51.5	3.48	0.20	33 37	—20 42.6	3.4	9	<14
5644	Z Librae	40 42	—20 48.8	3.49	0.19	38 5	—20 40.1	–	11	<13
5667	R Coronae	44 27	+28 27.8	2.47	0.19	42 36	+28 36.3	0.5	5.8	13.0
5675	V Coronae	45 57	+39 52.3	2.14	0.18	44 21	+40 0.7	5.9	7.2– 7.7	10.3–12.0
5677	R Serpentis	46 5	+15 26.3	2.76	0.18	44 1	+15 34.6	3.7	5.6– 7.6	15
5682	R Lupi	46 59	—35 59.9	3.88	0.18	44 5	—35 51.6	–	9	<11
5688	R Librae	47 56	—15 56.3	3.39	0.18	45 24	—15 48.1	2	9.2–10.0	<13
5704	RR Librae	50 39	—18 0.7	3.44	0.18	48 4	—17 52.6	3	8.4	14
5713	S Triang. Austr.	52 12	—63 29.5	5.35	0.18	48 12	—63 21.4	–	6.5	7.5
5732	T Coronae	55 19	+26 12.2	2.51	0.17	53 26	+26 20.1	1	2.0	9.5
5758	X Herculis	15 59 39	+47 30.8	1.81	0.17	58 18	+47 38.4	7	6.0	7.2
5761	Z Scorpii	16 0 8	—21 27.7	3.53	0.17	57 29	—21 20.1	–	9	12?
5770	R Herculis	1 44	+18 38.4	2.68	0.16	15 59 43	+18 45.9	2.0	8.0– 9.2	<13
5776	X Scorpii	16 2 40	—21 15.6	+3.53	—0.16	16 0 2	—21 8.3	–	>11	<13

No.	$M-m$	Elements of Maximum, Greenwich M.T. Epoch (Cal.)	(Julian)	Period	Inequalities	Remarks	Basis of Elements M	m	Dates included
4407	–	1868 June 11	=240 $3495^{d}.8$	$+317^{d}.2$ E		Periodic inequality?	12	–	1796, 1851–90
4492	85:	1883 Mar. 10	240 8880	+218.8 E			4	2	1882–93
4511	107.5	1860 Oct. 21	240 0705.8	+257.2 E	+20 sin(9°E+90°)		35	13	1843, 60–93
4521	68.5	1809 June 0	238 1934.8	+145.47E	+20 sin($\frac{2}{5}$°E+216°)+4.8 sin($\frac{45}{8}$°+343°)		87	28	1809–91
4536	0.295	1871 Aug. 16	240 4656.656	+ 0.882253 E			19	15	1871–92
4557	113.0	1860 June 24	240 0586.0	+226.1 E	+43 sin(5°.76E+181°.5)		54	32	1790, 1843–92
4596	88	1866 June 25	240 2778.0	+297.0 E		Periodic inequality	20	7	1813–31, 57–93
4731	–	. . . . . .	. . . . . .	. . . .			–	–	
4805	8.20	1866 Apr. 16	240 2708.2666	+17.2711 E			41	45	1866–72, 89–92
4816	–	1860 Feb. 15	240 0456.5	+250.5 E			15	–	1857–75, 83–92
4826	190	1891 July 17	241 1931.0	+425.15 E	-0.36E^2+15 sin(7°.5E+202°)		24	6	1784–1890
4847	157:	1852 Jan. 24	240 7512	+376.4 E	+20 sin(7°.5E+180°)		17	2	1795, 1824–93
4940	–	1889 Feb. 27	241 1061	+384 E			5	–	1875, 89–93
4948	–	1888 Mar. 25	241 0722	+340 E			6	–	1858, 85–91
5037	–	1879 May 13	240 7483	+217 E			8	–	1873, 79–92
5070	–	1880 May 25	240 7861	+305 E			7	–	1855, 80–91
5095	60:	1871 May 25	240 4573	+160.5 E			8	3	1871–78, 91, 92
5097	–	. . . . . .	. . . . . .	. . . .		Only one appearance known	–	–	
5156	79	1880 July 3	240 7900	+121.5 E			7	7	1880–84, 88–92
5157	130	1863 Apr. 13	240 1609.0	+274.0 E	-0.073E^2		32	6	1790, 1865–92
5190	135	1869 Aug. 29	240 3939	+269.5 E		Periodic inequality	31	7	1862–92
5194	97	1884 Aug. 30	240 9419	+256 E		Dunér's elements	4	3	1884–92
5237	101.5	1858 June 8	239 9839	+223.4 E	+10 sin(10°E+80°)		31	17	1858–90
5249	–	1882 Apr. 30	240 8566	+370 E			3	–	1880–89
5274	–	. . . . . .	. . . . . .	. . . .		Irregular	–	–	
5319	–	. . . . . .	. . . . . .	. . . .			–	–	
5338	80	1880 Mar. 25	240 7800.5	+173.8 E			11	5	1857, 80–93
5374	–	MIN. 1867 Oct. $25^d\,9^h\,17^m.5$		$+2^d\,7^h\,51^m\,22^s.8$ E		*Algol*-type	–	93	1797, 1837–88
5402	–	. . . . . .	. . . . . .	0.98			–	–	
5430	105	1878 Apr. 30	240 7105	+238 E			5	3	1878–92
5438	–	1861 June 22	240 0949	+327 E			4	–	1861, 78, 87, 88
5465	0.83	1871 July 14	240 4623.71	+ 3.38922 E			3	3	1871, 72, 91
5484	–	MIN. 1870 Mar. $25^d\,10^h\,38^m.5$		$+3^d\,10^h\,51^m\,12^s.4$E	$-0^s.0018$E^2	*Algol*-type	–	37	1858–89
5494	100:	1874 June 17	240 5692	+192.3 E			9	1	1874–93
5501	–	1828 Apr. 16	238 8829	+365.1 E	+59 sin(6°E+8°)		30	–	1794, 1828–92
5504	116	1860 Aug. 24	240 0647	+360.8 E			28	10	1860–92
5583	80	1878 July 17	240 7183	+163.6 E			13	1	1878–93
5593	–	1878 May 27	240 7132	+206 E			9	–	1878–92
5617	–	1873 July 23	240 5363	+226.2 E		Periodic inequality?	11	–	1849, 73–93
5644	–	1878 May 4	240 7109	+295 E			4	–	1878–86
5667	–	. . . . . .	. . . . . .	. . . .		Irregular	–	–	
5675	171	1878 Oct. 21	240 7279	+356.5 E			13	4	1857–61, 78–92
5677	151	1827 May 14	238 8491	+357,2 E	+35 sin(4°.5E+22°.5)		30	5	1783, 1827–90
5682	–	. . . . . .	. . . . . .	. . . .			–	–	
5688	–	1858 Apr. 6	239 9776	+730 E			4	–	1858–68, 84
5704	–	1885 June 17	240 9710	+277.0 E			5	–	1851, 85–91
5713	–	. . . . . .	. . . . . .	6.3			–	–	
5732	–	. . . . . .	. . . . . .	. . . .		New star of 1866	–	–	
5758	–	. . . . . .	. . . . . .	. . . .			–	–	
5761	–	1873 May 31	240 5306	+368 E			9	–	1851, 73–92
5770	–	1865 July 18	240 2436	+317.7 E	+20 sin(12°E+324°)		21	–	1825, 56–92
5776	–	1876 Apr. 19	=240 0634	+199.0 E			9	–	1876–91

No.	Star	1900.0		1900 Annual Variation		1855.0		Redness	Magnitude	
		R.A.	Decl.			R.A.	Decl.		Max.	Min.
		h m s	° '	s	'	h m s	° '			
5795	W Scorpii	16 5 55	—19 52.6	+3.50	—0.16	16 3 18	—19 45.3	–	10–11.2	<14.7
5826	T Scorpii	11 5	—22 43.6	3.57	0.15	8 25	—22 36.7	–	7.0	<12
5830	R Scorpii	11 41	—22 41.9	3.57	0.15	9 1	—22 35.0	0.9	9.4–10.5	<13
5831	S Scorpii	11 42	—22 39.0	3.57	0.15	9 2	—22 32.0	0	9.1–10.5	<13
5856	W Ophiuchi	16 2	— 7 27.5	3.23	0.15	13 36	— 7 21.3	6	8.9– 9.5	<13.5
5860	U Scorpii	16 45	—17 38.5	3.46	0.15	14 10	—17 1.9	–	9?	<12
5887	V Ophiuchi	21 10	—12 12.0	3.33	0.14	18 40	—12 5.5	6.6	7.0– 7.5	9.6–10.5
5889	U Herculis	21 22	+19 7.2	2.65	0.14	19 23	+19 13.6	6.5	6.6– 7.8	11.4–12.7
5903	Y Scorpii	23 49	—19 13.3	3.50	0.14	21 12	—19 7.1	–	10?	14
5912	*g* Herculis	25 21	+42 6.1	1.97	0.13	23 53	+42 12.2	3	4.7– 5.5	5.4– 6.0
5928	T Ophiuchi	28 1	—15 55.2	3.42	0.13	25 27	—15 49.2	–	10	<12.5
5931	S Ophiuchi	28 30	—16 57.0	+3.45	0.13	25 55	—16 51.1	1	8.3– 9.0	<13
5948	R Ursae minoris	31 18	+72 28	—0.84	0.13	31 57	+72 34.4	3.2	8.6– 9.0	10.5
5950	W Herculis	31 41	+37 32.4	+2.13	0.13	30 5	+37 38.1	3.2	8.0– 8.4	11.5–14
5952	Y Herculis	32 0	+ 7 18.6	2.91	0.13	29 50	+ 7 23.3	–	6.9	8.0
5955	R Draconis	32 23	+66 57.8	0.14	0.12	32 17	+67 3.5	2.0	6.5– 8.7	12–13
6005	S Draconis	40 46	+55 7.2	1.27	0.11	39 49	+55 11.8	–	7.3	9.2
6044	S Herculis	47 21	+15 6.6	2.73	0.10	45 18	+15 11.4	5.6	5.9– 7.5	11.5–13
6083	Ophiuchi	16 53 54	—12 44.4	3.36	0.10	51 23	—12 40.0	5	5.5	12.5
6132	R Ophiuchi	17 2 1	—15 57.6	3.44	0.08	16 59 27	—15 53.7	4.5	7.0– 8.1	<12
6181	*α* Herculis	10 5	+14 30.2	2.73	0.07	17 8 2	+14 33.5	5	3.1	3.9
6189	U Ophiuchi	11 27	+ 1 19.3	3.04	0.07	9 11	+ 1 22.6	0	6.0	6.7
6202	*u* Herculis	13 38	+33 12.3	2.21	0.07	11 58	+33 15.5	4	4.6	5.4
6268	Serpentarii	24 38	—21 23.7	3.59	0.05	21 57	—21 21.2	–	>1	?
6368	X Sagittarii	41 16	—27 47.6	3.77	0.03	38 26	—27 46.2	1	4	6
6404	Y Ophiuchi	47 17	— 6 7.1	3.22	—0.02	44 52	— 6 6.2	–	6.2	7.0
6472	W Sagittarii	17 58 38	—29 35.1	3.83	0.00	17 55 45	—29 34.9	1	4.8	5.8
6512	T Herculis	18 5 19	+31 0.2	2.27	+0.01	18 3 37	+30 59.9	1.4	6.9– 8.5	9.8–12.7
6573	Y Sagittarii	15 30	—18 54.3	3.53	0.02	12 51	—18 55.2	0	5.8	6.6
6624	T Serpentis	23 56	+ 6 14.0	2.93	0.03	21 44	+ 6 12.5	2.0	9.1–10.5	<13.5
6636	U Sagittarii	26 0	—19 11.7	3.54	0.04	23 21	—19 13.3	3.7	7.0	8.3
6682	X Ophiuchi	33 35	+ 8 44.4	2.87	0.05	31 26	+ 8 42.3	5	6.8	9.0
6726	T Aquilae	40 56	+ 8 38.3	2.87	0.06	38 47	+ 8 35.7	3.3	8.8	10.0
6733	R Scuti	42 9	— 5 48.7	3.21	0.06	39 45	— 5 51.4	4	4.7– 5.7	6.0– 9.0
6758	*β* Lyrae	46 23	+33 14.8	2.21	0.07	44 44	+33 11.8	1	3.4	4.5
6760	*κ* Pavonis	46 38	—67 21.5	6.21	0.07	41 58	—67 24.4	–	4.0	5.5
6794	R Lyrae	52 17	+43 48.8	1.82	0.08	50 55	+43 45.5	4	4.0	4.7
6806	S Coronae austr.	54 26	—37 5.3	4.06	0.08	51 22	—37 8.6	–	<9.5	13.0
6811	R Coronae austr.	55 9	—37 5.6	4.06	0.08	52 8	—37 8.8	–	9.8–11.5	13.2
6812	T Coronae austr.	55 14	—37 6.4	4.06	0.08	52 12	—37 9	–	<9.8	13
6834	V Aquilae	18 59 4	— 5 50.0	3.21	0.09	56 40	— 5 53.7	6.3*	6.5	8.0
6849	R Aquilae	19 1 33	+ 8 4.8	2.89	0.09	18 59 23	+ 8 0.8	5.5	5.9– 7.4	10.9–11.5
6903	T Sagittarii	10 28	—17 8.7	3.47	0.10	19 7 52	—17 13.2	6.5	7.6– 8.1	<11
6905	R Sagittarii	10 49	—19 29.0	3.52	0.10	8 11	—19 33.5	3.6	7.0– 8.0	12.5
6921	S Sagittarii	13 35	—19 12.4	3.51	0.11	10 57	—19 17.1	0	9.1–10.4	14.5
6923	Z Sagittarii	13 47	—21 6.6	3.56	0.11	11 7	—21 11.2	2	8.5	<12
6984	U Aquilae	23 58	— 7 15.0	3.23	0.12	21 33	— 7 20.3	0	6.4	7.1
7045	R Cygni	34 8	+49 58.5	1.61	0.13	32 56	+49 52.5	6.0	5.9– 8.0	<14
7085	RT Cygni	40 50	+48 31.9	1.70	0.14	39 33	+48 25.5	–	7?	11?
7101	11 Vulpeculae	43 28	+27 4.2	2.46	0.15	41 37	+26 57.7	–	3	?
7106	S Vulpeculae	44 18	+27 2.3	2.46	0.15	42 27	+26 55.7	3.0	8.4– 8.9	9.0–10.0
7120	*χ* Cygni	19 46 44	+32 39.7	+2.31	+ 0.15	19 45 0	+32 33.0	6.5	4.0– 6.5	13.5

No.	$M-m$	Elements of Maximum, Greenwich M.T.					Basis of Elements		
		Epoch (Cal.)	(Julian)	Period	Inequalities	Remarks	M	m	Dates included
			d	d					
5795	146:	1876 May 26=	240 6401	+222.3 E			11	2	1876–92
5826	–	. . . .		. . . .		New star of 1860 in *Messier* 80	–	–	
5830	–	1863 Mar. 25	240 1590.5	+224.5 E		Periodic inequality	22	–	1837–53, 63–91
5831	–	1837 June 1	239 2162.4	+176.7 E			23	–	1837, 39, 54–85
5856	–	1881 July 10	240 8272	+331.3 E			5	–	1823, 81–93
5860	–	. . . .		. . . .		Only one appearance known	–	–	
5887	–	1874 May 16	240 5660	+304 E			8	–	1874–92
5889	167	1860 Nov. 8	240 0723	+409 E		Periodic inequality?	16	6	1860–85, 93
5903	–	1876 June 26	240 6432	+359 E			3	–	1876, 80, 83
5912	–	. . . .		. . . .		Irregular	–	–	
5928	–	1860 Apr. 6	240 0507	+361 E			5	–	1860, 69–74, 83
5931	–	1857 June 29	239 9495	+233.8 E			7	–	1857–71, 89–93
5948	–	. . . .		. . . .		Irregularly periodic	–	–	
5950	125	1879 July 12	240 7543	+280.0 E	+25 sin(15°E+330°)		12	4	1857, 79–92
5952	–	. . . .		20.5			–	–	
5955	112	1877 Apr. 5	240 6715.8	+245.6 E			17	3	1790, 1858–92
6005	–	. . . .		. . . .			–	–	
6044	148	1856 Sept. 9	239 9202	+307.6 E	+45 sin(10°E+90°)		21	9	1840–90
6083	–	. . . .		. . . .		New star of 1848	–	–	
6132	–	1857 July 11	239 9567	+302.9 E			9	–	1847, 57–90
6181	–	. . . .		. . . .		Irregular	–	–	
6189	–	Min. 1881 July	$17^d\ 14^h\ 45^m.0$	$+20^h\ 7^m\ 42^s.56$E	$+80^m$ sin(0°.0225E+140°.0)		–	98	1863, 71, 81–92
6202	–	. . . .		. . . .		Irregularly periodic	–	–	
6268	–	. . . .		. . . .		New star of 1604	–	–	
6368	2.876	1870 Aug. 16	240 4291.78	+ 7.01185 E			388	367	1866–88
6404	6.250	1882 Sept. 4	240 8693.43	+ 17.12564 E		Sawyer's elements	25	26	1882, 86–91
6472	3.00	1866 Sept. 4	240 2849.45	+ 7.59460 E			–	–	
6512	78.0	1868 Mar. 9	240 3401.0	+164.85 E	+8 sin(7°E+59°)		37	28	1856–92
6573	1.80	1886 Sept. 25	241 0175.02	+ 5.7732 E			–	–	
6624	–	1861 May 11	240 0907.0	+342.3 E			15	–	1861–74, 83–89
6636	2.97	1870 July 1	240 4245.00	+ 6.7446 E			–	–	
6682	196	1886 Apr. 15	241 0012	+354 E			3	4	1854, 86–92
6726	–	. . . .		. . . .		Irregular	–	–	
6733	35	1886 Aug. 22	241 0141	+ 71.1 E			–	–	
6758	–	Min. 1855 Jan.	$6^d\ 14^h\ 28^m.7$	$+12^d\ 21^h\ 46^m\ 58^s.3$ E	$+0^s.4217\ E^2-0.00007\ E^3$		–	–	
6760	4.0	1871 Dec. 3	240 4765	+ 9.102 E			5	3	1871–73, 83, 91
6794	15.0	1887 Oct. 16	241 0561	+ 46.0 E			–	–	
6806	–	. . . .		. . . .			–	–	
6811	–	. . . .		30.6			–	–	
6812	–	. . . .		. . . .			–	–	
6834	–	. . . .		. . . .			–	–	
6849	144	1856 Aug. 5	239 9167	+351.0 E	$-0.34\ E^2$		16	5	1854–59, 69–92
6903	–	1866 Sept. 10	240 2855	+384 E			6	–	1865–70, 83
6905	158:	1866 July 18	240 2801	+268.7 E	+20 sin(14°.4 E+296°)		14	1	1849, 58–92
6921	110::	1866 Sept. 25	240 2870	+230.6 E		Periodic inequality	10	1	1863–71, 83–92
6923	–	. . . .		. . . .			–	–	
6984	2.25	1886 Sept. 20	241 0170.146	+ 7.02645 E		Yendell's elements	45	22	1886–92
7045	150	1854 Oct. 16	239 8508.9	+425.7 E			25	7	1817, 52–92
7085	–	. . . .		. . . .			–	–	
7101	–	. . . .		. . . .		New star of 1670	–	–	
7106	26.5	1865 Jan. 2	240 2239.0	+ 67.50 E	+4 sin(3°.6E+20°)		48	44	1836, 37, 62–86
7120	171.5	1763 June 3=	236 5136.5	+406.02 E	$+0.0075E^2$+25 sin(5°E+272°)		85	8	1687–1891

No.	Star	1900.0		1900 Annual Variation		1855.0		Red-ness	Magnitude	
		R.A.	Decl.			R.A.	Decl.		Max.	Min.
		h m s	° ′	s	′	h m s	° ′			
7124	η Aquilae	19 47 23	+ 0 44.9	+3.06	+0.15	19 45 5	+ 0 38.2	2	3.5	4.7
7149	S Sagittae	51 29	+16 22.2	2.73	0.16	49 25	+16 15.4	0	5.6	6.4
7192	Z Cygni	19 58 38	+49 45.9	1.70	0.17	19 57 21	+49 38.4	9.0*	7.1– 8.5	11.5–12
7220	S Cygni	20 3 24	+57 41.9	1.26	0.17	20 2 28	+57 34.2	5.1	8.8–11.3	<14.5
7234	R Capricorni	5 42	—14 33.8	3.37	0.17	3 10	—14 41.6	4	8.8– 9.7	<13
7242	S Aquilae	7 1	+15 19.4	2.76	0.18	4 57	+15 11.5	0.8	8.4–10.1	10.7–11.8
7252	W Capricorni	8 36	—22 16.8	3.54	0.18	5 57	—22 24.8	–	10.2–10.5	<14.7
7257	R Sagittae	9 30	+16 25.4	2.74	0.18	7 27	+16 17.4	0.8	8.5– 8.7	9.8–10.4
7259	RS Cygni	9 45	+38 27.8	2.18	0.18	8 7	+38 17.4	9.4*	6.8	8.3–10
7261	R Delphini	10 5	+ 8 47.1	2.90	0.18	7 55	+ 8 39.1	4.0	7.6– 9.0	11.1–12.8
7285	P Cygni	14 6	+37 43.3	2.21	0.18	12 27	+37 35.1	2	3–5	<6
7299	U Cygni	16 30	+47 34.7	1.86	0.19	15 7	+47 26.3	9.3	7.0– 8.1	9.4–11.6
7428	V Cygni	38 5	+47 47.1	1.93	0.21	36 28	+47 37.5	8.3	6.8– 9.5	13.5
7431	S Delphini	38 28	+16 43.7	2.76	0.21	36 24	+16 34.2	6.0	8.4– 9.5	10.4–12.0
7437	X Cygni	39 29	+35 13.6	2.35	0.21	37 44	+35 4.0	0	6.4	7.2–7.7
7444	T Delphini	40 43	+16 2.1	2.78	0.22	38 38	+15 52.5	2.0	8.2–10.3	<13
7446	U Delphini	40 53	+17 43.7	2.75	0.22	38 50	+17 34.0	7	6.4	7.3
7455	U Capricorni	42 34	—15 9.1	3.35	0.22	40 4	—15 18.8	–	10.2–10.8	<13
7456	RR Cygni	42 37	+44 30.2	2.07	0.22	41 3	+44 20.4	6.7*	8.1– 8.7	9.3– 9.7
7459	T Cygni	43 11	+34 0.4	2.39	0.22	41 24	+33 50.6	1	5.5?	6?
7468	T Aquarii	44 40	— 5 31.1	3.17	0.22	42 17	— 5 40.9	1.2	6.7– 8.7	12.4–13.0
7483	T Vulpeculae	47 13	+27 52.5	2.55	0.22	45 19	+27 42.3	0	5.5	6.5
7488	Y Cygni	48 4	+34 17.0	2.40	0.22	46 16	+34 7.0	0	7.1	7.9
7560	R Vulpeculae	20 59 56	+23 25.5	2.66	0.24	57 56	+23 14.9	2.0	7.5– 8.5	12.5–13.6
7571	V Capricorni	21 1 47	—24 19.3	3.50	0.24	20 59 9	—24 30.2	–	9	14?
7577	X Capricorni	2 50	—21 45.1	3.44	0.24	21 0 15	—21 55.8	–	9.5–10	<16.2
7609	T Cephei	8 13	+68 5.0	0.81	0.24	7 33	+67 54.4	6.3	5.2– 6.8	9.5–9.9
7659	T Capricorni	16 30	—15 35.0	3.32	0.25	14 0	—15 46.4	2	8.8– 9.7	13 5
7733	Y Capricorni	28 55	—14 25.1	3.28	0.26	26 27	—14 36.9	–	10?	14?
7754	W Cygni	32 14	+44 55.6	+2.27	0.27	30 34	+44 43.7	4.2*	5.0– 6.3	6.1–6.7
7779	S Cephei	36 28	+78 10.3	—0.67	0.27	36 57	+77 58.2	9.1	7.4– 9.2	11.5
7783	RU Cygni	37 19	+53 52.2	+2.00	0.27	35 46	+53 40.0	–	7.6	9.1
7787	Q Cygni	37 47	+42 23.1	2.36	0.27	36 1	+42 11.0	3	3	13.5
7795	RV Cygni	39 8	+37 33.6	2.48	0.27	37 18	+37 21.2	9.0*	7.1–7.8	8.8–9.3
7803	μ Cephei	40 27	+58 19.3	1.83	0.27	39 4	+58 7.0	6.2	4?	5?
7907	U Aquarii	57 52	—17 6.5	3.28	0.29	55 24	—17 19.5	–	10?	14?
7909	S Piscis austrini	21 58 2	—28 32.0	3.44	0.29	21 55 27	—28 44.9	–	8.7– 9.2	<11
7944	T Pegasi	22 4 1	+12 3.0	2.93	0.29	22 1 49	+11 49.9	3	8.5– 9.3	<13
7994	R Piscis austrini	12 19	—30 6.2	3.42	0.30	9 45	—30 19.6	–	5.7?	<11?
8068	S Lacertae	24 38	+39 48.2	2.62	0.31	22 40	+39 34.3	–	8.4	<12
8073	δ Cephei	25 27	+57 54.2	2.22	0.31	23 48	+57 40.4	2	3.7	4.9
8093	R Indi	28 53	—67 48.3	4.34	0.31	25 36	—68 2.1	–	9?	11?
8153	R Lacertae	38 50	+41 50.9	2.66	0.31	36 50	+41 36.8	1.8	8.3– 9.3	<13.5
8230	S Aquarii	51 45	—20 52.6	3.22	0.32	49 20	—21 7.0	4.0	7.7– 9.1	<12.5
8273	β Pegasi	22 58 55	+27 32.4	2.90	0.32	56 45	+27 17.8	2	2.2	2.7
8290	R Pegasi	23 1 38	+10 0.2	3.01	0.32	22 59 22	+ 9 45.7	4	6.9– 7.9	<13
8373	S Pegasi	15 29	+ 8 22.3	3.03	0.33	23 13 13	+ 8 7.6	1.7	7.3– 8.0	<13
8512	R Aquarii	38 39	—15 50.3	3.11	0.33	36 19	—16 5.3	4.3	5.8– 8.5	11?
8588	R Phœnicis	51 16	—50 20.6	3.13	0.33	48 55	—50 35.6	–	8.5?	11?
8591	V Cephei	51 44	+82 38.1	2.70	0.33	49 44	+82 23.0	–	6.2– 6.4	7.1
8597	V Ceti	52 47	— 9 31.1	3.08	0.33	50 29	— 9 46.1	–	8.5– 9.5	14?
8600	R Cassiopeae	23 53 19	+50 49.9	+3.02	+0.33	23 51 4	+50 34.9	6.5	4.8– 7.0	9.7–12

No.	M—m	Elements of Maximum, Greenwich M.T. Epoch (Cal.)	(Julian)	Period	Inequalities	Remarks	Basis of Elements M	m	Dates included
			d	d					
7124	$2^d\ 9^h$	1888 Jan. $6^d\ 12^h\ 32^m$		$+7^d\ 4^h\ 14^m\ 0^s.0$ E			–	–	
7149	3.40	1876 Dec. 13=	240 6602.60	+ 8.38320 E			81	55	1876–91
7192	125 :	1887 Mar. 11	241 0342	+265 E			6	4	1887–92
7220	144 : :	1865 June 29	240 2417	+322.8 E	+15 sin(15°E+45°)		30	1	1841, 60–92
7234	–	1859 Dec. 12	240 0391	+345 E		Elements uncertain	5	–	1859–68
7242	72	1865 Nov. 12	240 2553	+146.7 E			27	26	1855–91
7252	87 : :	1872 June 27	240 4972	+209 E			8	1	1872–91
7257	16.0	1859 Nov. 12	240 0361.0	+ 70.52 E	+5 sin(2°.5E+55°)	See notes	133	54	1859–92
7259	–	. . . .		. . . .		Irregularly periodic	–	–	
7261	–	1865 Aug. 26	240 2475	+285.5 E		Periodic inequality?	10	–	1851, 59–83, 93
7285	–	. . . .		. . . .		So called new star of 1600	–	–	
7299	229.0	1871 June 7	240 4586.0	+463.5 E	+12 sin(36°E+324°)		15	16	1871–92
7428	220	1881 June 12	240 8244	+418 E			8	2	1857, 81–92
7431	118	1866 Jan. 19	240 2661	+277.5 E			14	11	1863–92
7437	6.8	1886 Oct. 10	241 0190.55	+ 16.389 E			54	48	1886–90, 92
7444	–	1864 Sept. 11	240 2128	+331.9 E			16	–	1855, 63–92
7446	–	. . . .		. . . .		Irregular?	–	–	
7455	–	1857 Sept. 15	239 9573.5	+202.5 E		Periodic inequality	10	–	1852–59, 72–92
7456	–	. . . .		. . . .			–	–	
7459	–	. . . .		. . . .			–	–	
7468	88	1861 Nov. 16	240 1096.0	+203.3 E	+8 sin(7°.5E+255°)		19	4	1794, 1865–93
7483	1.30	1885 Nov. 2	240 9848.95	+ 4.4362 E			54	39	1885, 86, 91
7488	–	Min. 1886 Dec. $9^d\ 12^h\ 20^m\ 10^s$		$+1^d\ 11^h\ 57^m\ 22^s$ E*.		See notes.	–	66	1886–92
7560	6.20	1865 Sept. 18	240 2498.0	+136.90 E	+18 sin(4°E+80°)		27	10	1807, 10, 59–88
7571	–	1867 Aug. 18	240 3197	+157.1 E		Periodic inequality	10	–	
7577	117	1867 Aug. 17	240 3196	+218.1 E		Periodic inequality?	9	1	1867, 76–91
7609	193	1873 Aug. 29	240 5400	+383.3 E			13	7	1789, 1841–92
7659	135 :	1855 Oct. 21	239 8878	+269.2 E			14	1	1850–72, 83, 91
7733	–	1885 Sept. 5	240 9790	+206 E		Elements uncertain	3	–	1871, 85, 89
7754	72.9	1884 Nov. 30	240 9511.3	+130.8 E		Yendell's elements	21	17	1885–92
7779	257	1865 June 21	240 2409	+484 E			12	4	1789, 1841–93
7783	–	. . . .		. . . .			–	–	
7787	–	. . . .		. . . .		New star of 1876	–	–	
7795	–	. . . .		. . . .			–	–	
7803	–	. . . .		. . . .		Irregularly periodic	–	–	
7907	–	1875 Aug. 4	240 6105	+258 E		Elements uncertain	8	–	1875–92
7909	–	1890 Sept. 9	241 1620	+272 E		Holetschek's elements	2	–	1890, 92
7944	–	1864 Oct. 6	240 2151	+373 E		Periodic inequality	14	–	1822, 54–83
7994	–	. . . .		. . . .			–	–	
8068	–	. . . .		. . . .			–	–	
8073	$1^d 14^h 36^m$	1840 Sept. $26^d\ 10^h\ 50^m$		$+5^d\ 8^h\ 47^m\ 39^s.3$ E	$-0^s.0008\ E^2 - 0^s.000\,000\,15\ E^3$		289	278	1785–1889
8093	–	. . . .		. . . .			–	–	
8153	–	1883 Feb. 15	240 8857	+299.8 E			7	–	1856, 83–92
8230	–	1859 Dec. 16	240 0395	+279.7 E		Periodic inequality?	14	–	1798, 1853–92
8273	–	. . . .		. . . .		Irregular	–	–	
8290	172 :	1850 Dec. 26	239 7118	+380.0 E	+30 sin(10E°+200°)		19	5	1841–55, 66–92
8373	–	1864 Dec. 4	240 2210.5	+317.5 E			7	–	1864–84, 92
8512	–	1811 Nov. 30	238 2847.6	+387.16 E	+35 sin(10°E+235°)		23	–	1811–86
8588	–	. . . .		. . . .			–	–	
8591	220	1883 Mar. 16	240 8886	+360 E			5	6	1882–83, 90–93
8597	–	1879 Aug. 28	240 7590	+261 E			7	–	1879–92
8600	170	1854 July 14=	239 8414.0	+429.0 E	+23 sin(16°E+346°)		26	7	1850–92

* Subtract $3^h\ 24^m\ 44^s$ if epoch is odd.

NOTES TO THE CATALOGUE.

The following notes give, first, the facts with regard to the discovery of the variability of the several stars. For the stars contained in Schönfeld's Second Catalogue, the name of the discoverer and the date, only, are given; except in special instances where, from any doubt that might exist as to the variability, the facts as to independent confirmation are added. For variables announced since that time, pains have been taken to supply also the name of the observer by whom the suspicion or discovery was first confirmed. The imperative necessity for requiring such independent verification, as a criterion for assigning Argelander's letters and for insertion in the catalogue, has been adverted to on so many occasions, and the danger of departing from this course has been so forcibly illustrated in many instances, that the matter need not be further insisted upon here.

To facilitate the identification of the variables in their fainter stages, I have given, in as many cases as was convenient or possible, the positions, relative to the variable, of the neighboring fainter stars. (See *A.J.* VIII, 114.)

The other data in the notes relate mainly to peculiarities of the light-curves, etc. If space had permitted, these would have been much more complete. In the next edition of the catalogue it is hoped to incorporate, in compact form, the results of numerous original investigations in this direction, which will be useful to observers.

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100. Disc. by Chandler, 1881; conf. by Sawyer. Occasionally rudely periodic, 60–70 days, at other times irregular.

107. Disc. by Krueger, 1870. Light-curve flat at max., with sometimes a sec. min. near this phase. 8^{M} foll. 10^{s}, $0'.5$ N.

112. Disc. at Bonn, 1858. Sometimes has sec. phases following principal max. one or two months. 12^{M} pr. 3^{s}, $2'$ S; 9^{M} pr. 31^{s} on parallel.

114. Susp. by Borrelly, 1872; proved by Schönfeld. 12^{M} foll. 2^{s}, $4'.5$ S; 12^{M} pr. 3^{s}, $6'$ N.

116. Tycho's star. Probable place according to Argelander. Possibly identical with a $10^{M}.5$ now visible $0'.8$ N.

161. Disc. by Luther, 1855. Schönfeld's obsns. show irregular periods, $2\frac{1}{2}$–5 mos.

209. Disc. by Birt, 1831; conf. by Sir J. Herschel and others. Var. only occasionally evident. Argelander found per. 79^{d}, uncertain.

224. Disc. by Hartwig, 1885. New star in *Andromeda* nebula.

243. Disc. by Espin, 1887; conf. by Chandler.

320. Disc. by Ceraski, 1880. *Algol*-type. Light-curve unusually flat at min., and unsymmetric; decrease more rapid than increase. Oscillations occupy one-sixth of period, or 10 hours; nearly stationary for 2 hours at minimum. See investigations *A.J.* IX, 49 and XIII, 45.

432. Disc. at Bonn, 1861. Light-curve variable. $9^{M}.6$ foll. 20^{s}, $2'$S; 12^{M} pr. 15^{s}, $0'.3$ S.

434. Disc. by Hind. 1851. $11^{M}.5$ foll. $0^{s}.5$, $0'.7$ N; 12^{M} directly S.

466. Disc. by Peters, 1880; conf. by Parkhurst. For stars of ident. see *A.N.* 99, 114.

494. Disc. by Gould, 1872; conf. by Sawyer.

513. Disc. by Hind, 1850. 11^{M} foll. 7^{s}, $0'.5$ N; 9^{M} pr. 9^{s}, $4'$ N.

678. Susp. by Fleming, 1890; conf. by Yendell and Reed. Period perhaps about 6 mos.

715. Disc. by Peters, 1865. $9^{M}.5$ pr. 10^{s}, $6'$S; $10^{M}.5$ foll. 5^{s}, $4'.5$ N.

782. Disc. at Bonn, 1857. Light-curve flat near max., 6^{M} pr. 23^{s}, $0'.7$ S.

793. Disc. by Safarik, 1882; conf. by Chandler and Schwarzchild. Either irregular or rudely periodic. with period of several months.

806. Disc. by Fabricius, 1596; recognized as periodically var. by Holwarda, 1638. Principal epoch of elements in catalogue corresponds to Ep. 227 of Argelander. $9^{M}.1$ foll. $7^{s}.7$, $10''$ N.

814. Disc. by Krueger, 1872. Probably irregular. Safarik and Hagen think it is rudely periodic; period long, $2\frac{1}{3}$ years. 10^{M} foll. 2^{s}, $1'.1$ N.

845. Disc. by Argelander, 1866. 11^{M} pr. 12^{s}, $5'$ N.

893. Disc. by Sawyer, 1885; conf. by Chandler.

906. Susp. by Espin, 1890; proved by Yendell and Knott.

976. Disc. by Auwers, 1870. Light-curve very flat near max.

1072. Disc. by Schmidt, 1854. Schmidt's period of $32^{d}.98$ not conf. by Schönfeld's obsns.

1090. Susp. by Montanari, 1669; independently disc by Goodricke, 1782. Additional term of elements, $+3^{m}.5$ $\sin(\frac{1}{6}°E+90°.33)$. Principal epoch of elements corresponds to Ep. 11210 of Argelander. See investigations, *A.J.* VII, 165–183; XI, 113–126. Light oscillations occupy a little over 9 hours.

1113. Disc. by Schaeberle, 1892; conf. by Glasenapp. Position only rudely known.

1222. Disc. by Schönfeld, 1861. 12^{M} foll. 5^{s}, $0'.2$ S; 12^{M} foll. 4^{s}, $1'.2$ S; 12^{M} pr. 12^{s}, $0'.5$ S.

1367. Disc. by Gould, 1876; conf. by Chandler, also Yendell.

1411. Disc. by Baxendell, 1848. Period certainly subject to inequalities, whose law it is not yet possible to determine. Deviations from uniform elements sometimes amount to 3 hours. The light-oscillations occupy 10 hours.

1537. Disc. by Hind; conf. by Auwers and Chacornac, 1861. A supposed variable nebula (Hind and D'Arrest) precedes $2^{m}\,38^{s}$, $6'.5$ S.

1574. Susp. by Espin, 1886; conf. by Gage, Chandler and Parkhurst, although there is some doubt and confusion about its exact place. The region within 15′ should be watched.

1577. Disc. by Hind, 1849. 8^{M} pr. 15^{s}, 5′.5 S; 10^{M} foll. 3^{s}, 2′ N.

1582. Disc. by Oudemans. 1855. Townley thinks period is one-half of that in table. The small value of *M—m* seems to favor this hypothesis. although there are no obsns. of max. to confirm it. $11^{M}.5$ foll. 9^{s}, 1′ S; $11^{M}.5$ foll. 4^{s}, 0′.7 S; 12^{M} pr. 6^{s}, 1′ N.

1623. Disc. by Espin, 1891; conf. by Dunér. Elements provisional and uncertain, from Dunér's two max.

1635. Disc. by Ragoonathachari, 1867; conf. by Roberts.

1654. Disc. by Gould, 1874; conf. by Roberts. Period about 11 mos., by Roberts's obsns.

1717. Disc. by Auwers, 1871. $12^{M}.5$ foll. 11^{s}, 1′ S; $11^{M}.5$ foll. 10^{s}, 3′.5 N.

1761. Disc. by Hind, 1848. 11^{M} foll. 11^{s}, 0′.3 N; 12^{M} pr. 7^{s}, 0′.6 S.

1768. Susp. by Fritsch, 1821; conf. by Schmidt. 1843: independently disc. by Heis, 1847. Variations irregular. often unnoticeable during many months.

1771. Disc. by Schmidt. 1855. Hind's "crimson star." Accurate obsns. of max. and min. difficult.

1855. Disc. at Bonn, 1862. Schönfeld notes. and Chandler's obsns. confirm, the unusual phenomenon of a "standstill" during increase at about 9^{M}, from 2 to 4 mos. before max. 9^{M} pr. 5^{s}, 0′.6 S.

1923. Disc. by Dunér, 1881; conf. by Chandler. Period irregular; probably over 400 days, with secondary phases.

1944. Disc. by Webb, 1870; conf. by Schönfeld. Marked irregularities, and secondary phases in light-curve. 10^{M} about 1′ N; $9^{M}.5$ pr. $2^{s}.5$, 0′.4 S.

1953. Disc. by Anderson, 1892. A secondary max. occurred in Aug., 1892. $9^{M}.2$. No apparent change in 6 mos. prec. Apr., 1893, according to Parkhurst.

1981. Disc. by Espin, 1891; conf. by Yendell. Elements mere guess-work. from Yendell's 3 max.

1986. Disc. by Bond. 1863. Schmidt's obsns. 1868–81, and Chandler's 1883–84. certainly confirm. While this is the only star in the nebula of *Orion* inserted in the Catalogue, there is little doubt that several others are variable. But the subject is a very intricate one, and requires especial investigation. See note to "unconfirmed list" with regard to Stone's and Schmidt's observations.

2013. Susp. by Espin. 1891: proved by Yendell. Elements consistent with DM. obsns., but numeration of periods not certain.

2098. Disc. by Sir J. Herschel, 1840. Argelander found period of 196^{d}. Schönfeld thought periodicity questionable.

2100. Disc. by Gore, 1885; generally confirmed. Elements deduced from combination of obsns. with various negative data, 1797–1857.

2213. Disc. by Schmidt, 1865. Elements will satisfy Schmidt's min. of 1844, which Schönfeld's would not.

2258. Susp. by Espin, 1886; proved by Chandler, 1891; and Yendell, 1893. Elements given are mere guess-work. They satisfy hypothetically all present data.

2266. Disc. by Schönfeld, 1883; conf. by Chandler.

2279. Disc. by Gould, 1871. Elements of First Catalogue retained, although not definitive. Yendell gets 1885 Apr. 2.68 + 27.0059 E.

2362. Disc. by Schmidt. 1861. In southerly end of the nebula *h* 399.

2375. Disc. by Winnecke. 1867. Schönfeld's obsns. partly confirm partly contradict Winnecke's elements. Yendell's obsns. also render them doubtful. The star requires further investigation before the question can be settled.

2478. Disc. by Krueger, 1870–74; conf. by Schönfeld. 10^{M} foll. 20^{s}, 2′.3 N; 10^{M} pr. 11^{s}, 3′.5 N.

2509. Disc. by Schmidt. 1847. Elements of First Cat. retained. Definitive investigation not completed.

2528. Disc. by Hind, 1848. Light-curve variable. Variations near max. frequently very slow. 12^{M}, 2′.5 N; $12^{M}.5$ pr. 4^{s}, 1′ S; 9^{M} foll. 25^{s}, 3′ N.

2539. Disc. at Bonn, 1855. Light-curve flat at max. Obsns. of Lalande and Bessel cannot yet be certainly included in calculation of elements.

2583. Disc. by Gould, 1872; conf. by Williams and Roberts.

2610. Disc. by Sawyer, 1887; conf. by Chandler. Elements of Supplement (*A.J.* 216) retained, as recent obsns. give no certain correction. Light-oscillations occupy 5 hours.

2625. Disc. by Baxendell, 1880; conf. by Knott and Chandler.

2676. Disc. by Gould. 1873. Elements of First Cat. retained. Definitive investigation not completed. Light-curve has rudely alternating bright and faint minima.

2684. Disc. by Hind, 1856. Light-curve flat at max. $9^{M}.5$ foll. 19^{s}. 4′ N; $9^{M}.3$ pr. 25^{s}, 3′ N.

2691. Disc. by Schönfeld. 1865. $12^{M}.7$ pr. 1^{s}. 0′.3 S; $12^{M}.2$ foll. 4^{s}, 0′.1 N.

2735. Disc. by Baxendell. 1879; conf. by Schmidt. Period and light-curve very irregular, with secondary max. and min. Elements uncertain.

2742. Disc. by Hind, 1848. $11^{M}.5$ foll. 4^{s}, 0′.6 S: 12^{M} pr. 5^{s}, 1′.6 N.

2780. Disc. by Hind, 1848. A halt frequently occurs during increase, at about $9^{M}.5$. $12^{M}.5$ pr. 1^{s}. 2′.3 S; 11^{M} pr. 12^{s}, 3′ N.

2783. Disc. by Gould, 1872?

2815. Disc. by Hind. 1855. Light-variation of a unique character. The star remains at or near min., about 13^{M}, most of the time. suddenly brightens to about $9^{M}.3$, and diminishes again in 5–12 days to min. Irregular periods. from two to five mos., average 86.3 days. For purpose of approx. prediction the epoch of last observed max. is given as epoch of catalogue. For comparison-stars and light-scale see Winnecke, *A.N.* 1120.

2852. Disc. by Williams, 1886; conf. by Roberts. The former thinks period is 4½ days; the latter, about half of this.

2857. Disc. by Pickering, 1881; conf. by Chandler. Elements uncertain. 10^M foll. 26^s, 4′ N; 11^M pr. 16^s, 1′.5 N; 13^M foll. 2^s, 1′.5 S.

2946. Disc. by Schwerd, 1829. 10^M foll. 6^s, 4′.4 S; 12^M pr. 4^s, 1′.5 S.

2976. Disc. by Auwers, 1870. Occasionally secondary phases near max. 11^M foll. 4^s on parallel; $10^M.5$ foll. 18^s, 0′.3 N.

3060. Disc. by Chacornac, 1853. Light-variation, occasionally at least, slow near max. 11^M pr. 3^s, 7′ N.

3109. Disc. by Hind, 1848. Schönfeld's elements retained, since 6 min. by Yendell in 1890 give unimportant deviations. Light-oscillations occupy 21½ hours.

3128. Susp. by Weiss; proved by Holetschek, 1890. Period just about a year. This letter assigned because the var. of the star to which the letter *R* was assigned, (*Uran. Argent.* p. 297,) has not yet been confirmed.

3170. Disc. by Hind, 1848. Var. near max sometimes slow, sometimes rapid. 11^M pr. 12^s on parallel; 12^M foll. 7^s, 0′.3 N.

3184. Disc. by Hind, 1851. 10^M foll. 6^s, 3′ N; $10^M.5$ pr. 4^s, 2′.5 N.

3186. Disc. by Hind, 1850. Elements give minimum-epoch only, as light-curve is too flat near max. to determine the latter.

3407. Disc. by Paul, 1888; conf. by Sawyer. Period of Supplement to First Cat. (*A.J.* 216) retained, correcting Epoch by $-17^m.4$. Light-oscillations occupy about 3½ hours.

3409. Disc. by Gould, 1871; conf. by Roberts. Roberts's obsns. not entirely consistent with Gould's period of 4.25 days.

3418. Disc. by Gould, 1871; conf. by Tebbutt.

3477. Disc. by Schönfeld, 1863. $10^M.5$ foll. 10^s, 2′ N.

3493. Disc. by Koch, 1782. The periodical inequality of the elements is very certain.

3495. Disc. by Gould, 1871; conf. by Roberts.

3567. Disc. by Becker, 1882; conf. by Chandler. $11^M.5$ foll. 5^s, 1′.2 N.

3633. Disc. by Gould, 1872; conf. by Roberts.

3637. Disc. by Gould, 1871; conf. by Roberts. Light-curve regular.

3712. Disc. by Peters, 1876. Schönfeld thought it variable. Certainly seen by no one except Peters and the DM. observers. The writer has never been able to see the star, although it was sought for many times in different years. Parkhurst's experience is similar. The variability is extremely doubtful.

3796. Disc. by Gould, 1871; conf. by Espin and Yendell. Espin's period not confirmed.

3825. Disc. by Pogson, 1853. Light-curve very variable.

3847. Disc. by Burchell, 1827. Fluctuations very capricious.

3881. Susp. by Gould; proved by Chandler. 1888. Large irregularities in period. Elements uncertain.

3890. Disc. by Peters, 1880; conf. by Parkhurst. A max. obsd. by Yendell, 1893, contradicts Parkhurst's period. For stars of identification see *A.N.* 99, 114.

3908. Disc. by Gould, 1877; conf. by Upton and Roberts. The latter thinks periods is about 18^h.

3934. Disc. by Winnecke, 1861. Variations very small, and, according to some observers, doubtful. Schönfeld found, very uncertainly, period of 160^d, from Winnecke's obsns. *α Crateris* pr. 43^s, 1′.2 N; 9^M pr. 5^s; $8^M.5$ foll. 10^s, 2′.5 S.

3994. Disc. by Chacornac, 1856. Increase apparently slower than decrease by Chandler's obsns. $11^M.5$ foll. 6^s, 1′.7 S.

4160. Disc. by Peters, 1862. Variation not confirmed by any other observer, and indeed, from obsns. of Schönfeld, Parkhurst and Chandler — none of whom have ever certainly seen the star — is subject to considerable doubt.

4300. Disc. by Peters, 1871; conf. by Schönfeld and Chandler. A period of about 340^d is consistent with a large part of the very defective data. $11^M.5$ foll. 2^s, 0′.4 N.

4315. Disc. by Schönfeld, 1856. $7^M.5$ pr. 13^s, 2′.2 N.

4377. Disc. by Boguslawski, 1849. 11^M pr. 8^s, 2′ N; 12^M foll. 1^s, 2′ N; $11^M.5$ foll. 12^s, 2′ N; $11^M.5$ pr. 2^s, 4′ N.

4407. Disc. by Karlinski, 1867. Increase rapid. 8^M pr. 5^s, 3′.5 S; 10^M pr. 5^s, 0′.5 N; 8^M foll. 18^s, 1′ S.

4492. Disc. by Henry, 1874; conf. by Chandler. 8^M foll. 19^s, 1′ S; 11^M foll. 12^s, 2′.5 N.

4511. Disc. at Bonn, 1860.

4521. Disc. by Harding, 1809. See investigation *A.J.* VIII, 164.

4536. Disc. by Gould, 1871; conf. by Upton.

4557. Disc. by Pogson, 1853.

4596. Disc. by Harding, 1831. Periodic inequality of small range indicated. 10^M pr. 9^s, 1′ N.

4731. Susp. by Espin, 1891; proved by Yendell.

4805. Disc. by Schönfeld, 1866. Light-curve very regular.

4816. Disc. by Goldschmidt, 1857. Increase somewhat irregular, decrease more uniform. Star isolated, and identification easy.

4826. Susp. by Montanari, 1672 (1670?); proved by Maraldi, 1704. Elements of catalogue are based on obsns. since 1784 only, the attempt to reconcile Hevel's, Montanari's and Maraldi's max. having been given over for the present. The principal epoch of catalogue corresponds to Ep. 170 of investigation in *A.N.* 103, 225.

4847. Disc. by Hind, 1852.

4940. Disc. by Sawyer, 1888; conf. by Yendell.

4948. Disc. by Espin, 1888; conf. by Chandler.

5037. Disc. by Peters, 1880; conf. by Parkhurst.

5070. Disc. by Palisa. 1880; conf. by Chandler. 9^{M} pr. 12^{s}, 2′ S; 10^{M} pr. 7^{s}, 2′ N.

5095. Disc. by Gould, 1871; conf. by Roberts.

5097. Disc. by Baxendell, 1860. Only one appearance known. Schönfeld suggested that it may belong to the class of new stars.

5156. Disc. by Baxendell, 1859; conf. by Chandler. 1888, and Yendell, 1893. $7^{M}.3$, directly south 2′.8, renders obsn. difficult.

5157. Disc. at Bonn, 1860. Quadratic term of elements very certainly established.

5190. Disc. by Hencke, 1858. Light-curve somewhat irregular.

5194. Disc. by Dunér, 1884; conf. by Chandler. Observed max. show considerable deviations.

5237. Disc. at Bonn. 1858.

5249. Disc. by Schönfeld. 1882; conf. by Chandler.

5274. Disc. by Schmidt, 1867; conf. by Schwab.

5319. Disc. by Gould, 187– (?); conf. by Roberts.

5338. Disc. by Baxendell, 1880; conf. by Schwab. Parkhurst suggests period to be lengthening ($P = 173^{d}.5 + 0^{d}.16\,E$).

5374. Disc. by Schmidt. 1859. Epoch of catalogue elements corresponds to Ep. 391 of Schönfeld. Schmidt found an inequality of 9 yrs. cycle in period. I suspect that this is not real, but a subjective effect, dependent on hour-angle at which min. are obsd. The subject is reserved for definitive investigation. Light-oscillations occupy 12 hours.

5402. Disc. by Gould, 187– (?); conf. by Roberts, who also confirms Gould's period.

5430. Disc. by Palisa, 1878; conf. by Chandler. Period of first catalogue was 723^{d}. Townley discovered the subdivision. $10^{M}.5$ foll. 7^{s} on parallel; 13^{M} pr. 4^{s}, 0′.2 N; $13^{M}.5$ pr. 1^{s}, 1′ N.

5438. Disc. by Bauschinger, 1887; conf. by Chandler. Period uncertain.

5465. Disc. by Gould, 1871; conf. by Roberts.

5484. Disc. by Winnecke, 1869. Elements of supplement, *A.J.* 216, retained, as they represent subsequent obsns. to date, without appreciable certain correction. See investigation *A.J.* IX. 97. Light-oscillations occupy nearly 10 hours.

5494. Disc. by Borrelly, 1872. 13^{M} pr. 2^{s}, 2′ N; $12^{M}.5$ foll. 5^{s}. 2′.5 N.

5501. Disc. by Harding, 1828. Increase more rapid than decrease. 11^{M} pr. 8^{s}, 0′.5 N; $12^{M}.7$ foll. 2^{s}, 0′.4 N.

5504. Disc. by Hencke, 1860.

5583. Disc. by Peters, 1878; conf. by Parkhurst. Townley suggested period of 169^{d}, in place of Peters's of 295^{d}. Parkhurst suggests the elements 1878 July 27 + 112.6 E.

5593. Disc. by Peters, 1878; conf. by Parkhurst.

5617. Disc. by Peters, 1878; conf. by Chandler.

5644. Disc. by Peters. 1879. Elements very uncertain. S. DM. gives R. A. 10^{s} smaller. Identification not certain.

5667. Disc. by Pigott, 1795. Remains frequently nearly unchanged, near max., then diminishes at irregular intervals suddenly to min., and after repeated large oscillations resumes its normal unchanging condition.

5675. Disc. by Dunér. 1878; conf. by Schmidt. Secondary phases near max. sometimes marked.

5677. Disc. by Harding. 1826. Star isolated and identification easy.

5682. Disc. by Gould. 1884.

5688. Disc. by Pogson, 1858. Not recently observed, and elements consequently not trustworthy for prediction. 12^{M} pr. 3^{s}, 1′.2 S.

5704. Disc. by Peters, 1885; conf. by Parkhurst.

5713. Disc. by Gould. 187– (?); conf. by Roberts, who gives period as $6^{d}.3$.

5732. Disc. by Birmingham. 1866. See note to Schönfeld's Second Catalogue for history of its appearance.

5758. Disc. by Gore, 1890; conf. by Yendell.

5761. Disc. by Peters, 1883; conf. by Parkhurst.

5770. Disc. at Bonn, 1855. Identification easy.

5776. Disc. by Peters, 1876; conf. by Parkhurst.

5795. Disc. by Palisa. 1870; conf. by Schmidt. 10^{M} pr. 8^{s}, 1′ N; 10^{M} foll. 10^{s}, 3′ S.

5826. Disc. by Auwers, 1860, independently by Pogson, one week later. Position, $0^{s}.29$ foll. 2″.7 N of the center of cluster *Messier* 80. Not since seen.

5830. Disc. by Chacornac, 1853. Light-curve very variable; marked secondary phases. Increase from 12^{M} rapid. 8^{M} pr. 24^{s}, 2′ N; 9^{M} foll. 10^{s}, 3′ N.

5831. Disc. by Chacornac, 1854. $9^{M}.4$ foll. 9^{s}, 0′.2 N.

5856. Disc. by Schönfeld, 1881; conf. by Chandler. 11^{M} pr. 13^{s} on parallel; 12^{M} foll. 13^{s}, 4′ N; 10^{M} foll. 34^{s}, 1′ N.

5860. Disc. by Pogson, 1863. Decreased from 9^{M} to invisibility in 12 days. Not seen by any one else.

5887. Disc. by Dunér. 1881; conf. by Chandler.

5889. Disc. by Hencke. 1860. Elements will not satisfy Bessel's obsn., hence period is probably variable. 9^{M} pr. 12^{s}, 3′.3 N.

5903. Disc. by Peters, 1876; conf. by Chandler. Elements very uncertain.

5912. Disc. by Baxendell, 1857.

5928. Disc. by Pogson. 1860. Elements very uncertain. 10^{M} foll. 5^{s}, 9′ S; 10^{M} pr. 5^{s}, 2′.5 S.

5931. Disc. by Pogson, 1854. Recent obsns. confirm Schönfeld's elements, which are retained. Light-curve variable. $11^{M}.5$ pr. 6^{s}, 3′ N; 12^{M} pr. 13^{s}. 0′.2 N.

5948. Disc. by Pickering, 1881; conf. by Chandler. Period 4 to 6 mos., very irregular.

5950. Disc. by Dunér, 1880; conf. by Chandler.

5952. Disc. by Chandler, 1882; conf. by Yendell. The former, in 1882–83, found period $20^{d}.5$; the latter in 1889–93, period of $20^{d}.6$.

5955. Disc. by Geelmuyden, 1876; conf. by Hartwig. $8^{M}.5$ foll. 35^{s}, 1′.5 S; 11^{M} foll. 2^{s}, 3′ S.

6005. Susp. by Espin, 1892; proved by Yendell.

6044. Disc. at Bonn, 1856. Decrease unusually rapid immediately after max. $9^{M}.7$ foll. 9^{s}, 1′.4 S; 6^{M} foll. 11^{s}, 1′.9 N.

6083. Disc. by Hind, 1848. At present visible as $12^{M}.5$, without change since 1867.

6132. Disc. by Pogson, 1853. $10^{M}.5$ foll. 6^{s}, 4′ S; $10^{M}.5$ pr. 2^{s}, 6′ S. Also a small nebula, not in Herschel's G.C. or Dreyer's supplement. foll. 36^{s}, 2′ S.

6181. Disc. by W. Herschel, 1795. Very irregular oscillations in periods of 2 to 4 mos.

6189. Disc. by Gould, 1871; conf. in 1881 by Sawyer, who also first recognized its character as of the *Algol*-type. See investigations *A.J.* VII, 129–140, and XIII, 46. Light-oscillations occupy 5 hours.

6202. Disc. by Schmidt, 1869 (?). Schmidt gave period about 37–40 days. Very rapid secondary oscillations near min. remarked by Schmidt, and confirmed by Schwab.

6268. Disc. by Brunowski and Fabricius, 1604. See note to Schönfeld's Second Catalogue.

6368. Disc. by Schmidt, 1866; obsns. to 1892 give no certain corr. to Schonfeld's elements.

6404. Disc. by Sawyer, 1888; conf. by Chandler.

6472. Disc. by Schmidt. 1866; obsns. to 1892 give no correction to elements of supplement, *A.J.* No. 216.

6512. Disc. at Bonn, 1857. 10^{M} pr. 3^{s}, 0′.9 N.

6573. Disc. by Sawyer, 1886; conf. by Chandler. Elements nearly definitive.

6624. Disc. by Baxendell, 1860. Recent obsns. confirm Schönfeld's elements, which are retained. $11^{M}.5$ foll. 3^{s}, 0′.1 N.

6636. Disc. by Schmidt, 1866. Elements not quite definitive.

6682. Disc. by Espin, 1886: conf. by Chandler.

6726. Disc. by Winnecke. 1860. Irregularly variable in period of 3 to 5 mos.

6733. Disc. by Pigott, 1795. Argelander found bright and faint minima, usually alternating, and this has been confirmed by all subsequent observers. Provisional elements of First Catalogue retained, pending the completion of full discussion.

6758. Disc. by Goodricke, 1784. Light-curve double. Secondary min. about midway. Reed's provisional corr. of Argelander's elements retained, pending final discussion.

6760. Disc. by Thome, 1872; conf. by Upton.

6794. Disc. by Baxendell, 1856. Elements of First Catalogue retained.

6806. Disc. by Schmidt, 1866. The period of 6^{d}, found from his earlier obsns., not conf. by the later ones.

6811. Disc. by Schmidt, 1866. Period given in Catalogue is Schmidt's.

6812. Disc. by Schmidt, 1876.

6834. Recognized by various observers, Knott, 1871; Schmidt, 1872; Safarik, 1884; Sawyer, 1892.

6849. Disc. at Bonn, 1856. Secondary fluctuations near max. Light-curve very variable. $9^{M}.6$ pr. 12^{s}, 0′.3 S; $10^{M}.6$ pr. 4^{s}, 0′.5 N.

6903. Disc. by Pogson, 1863. Lack of recent obsns. makes prediction uncertain. $11^{M}.5$ foll. 10^{s}, 0′.5 N.

6905. Disc. by Pogson, 1858. 11^{M} pr. 1^{s}, 0′.4 S; $10^{M}.8$ pr. 4^{s}, 1′ N.

6921. Disc. by Pogson, 1860. 11^{M} foll. 24^{s}, 2′.5 S.

6923. Disc. by Peters, 1888; conf. by Pickering. No elements possible, from data available.

6984. Disc. by Sawyer, 1886; conf. by Chandler.

7045. Disc. by Pogson, 1852. *θ Cygni* pr. 22^{s}, 0′.7 N; 9^{M} foll. 2^{s}, 1′.5 N.

7085. Disc. by Pickering, 1890: conf. by Porro (?).

7101. Disc. by Anthelm, 1670. See note to Schönfeld's Second Catalogue.

7106. Susp. by Hind, 1861; proved by Baxendell, 1862. Periodical term of elements uncertain.

7120. Disc. by Kirch, 1686. See investigation *A.J.* X, 103. $11^{M}.5$ pr. 10^{s}, 1′ 9 S; $11^{M}.5$ foll. 3^{s}, 1′ S; $11^{M}.5$ foll. 6^{s}, 0′.1 N.

7124. Disc. by Pigott, 1784. Elements of First Catalogue retained, pending definitive discussion.

7149. Disc. by Gore, 1885; conf. by Chandler.

7192. Disc. by Espin, 1887; conf. by Baxendell, Jr.

7220. Disc. at Bonn, 1860. Coefficients of periodical inequality only approximate. Secondary phases near max. $8^{M}.9$ foll. 1^{s}, 0′.8 N.

7234. Disc. by Hind, 1848. Want of recent obsns. makes elements uncertain for prediction. 13^{M} dist. 20″, pos.-angle 355°.

7242. Disc. by Baxendell, 1863. Extraordinary and unexplained irregularities in period. 9^{M} foll. 1^{s}, 1′.5 S.

7252. Disc. by Peters, 1872; conf. by Parkhurst and Chandler. For stars of identification see *A.N.* 109. 120.

7257. Disc. by Baxendell, 1859. Double light-curve, like *β Lyrae*. Second max. and second min. follow principal ones about 35^{d}, respectively. Reversals of light-curve occurred in 1874 and 1883, so that between these dates the secondary minima were fainter than the principal minima.

7259. Disc. by Espin, 1887; conf. by Chandler. Dunér thinks period may be 380^{d}; Parkhurst, 120^{d}; but it is doubtful whether the star is regularly periodic. Place from Bessel. DM. decl. is 2′.4 smaller.

7261. Found by Hencke. 1851, and suspected to be an asteroid, until Schönfeld, 1859, proved variability. 12^{M} pr. 2^{s}, 1′ S.

7285. Disc. by Janson, 1600.

7299. Disc. by Knott, 1871. Knott thinks brightness at minimum is systematically variable. $8^{M}.5$ foll. 5^{s}, 0′.7 N.

7428. Disc. by Birmingham, 1881: conf. by Schmidt. Second max. follows principal one about two months.

7431. Disc. by Baxendell, 1860. $8^{M}.3$ pr. 1^{s}, 0′.9 N.

7437. Disc. by Chandler, 1886; conf. by Yendell. The former finds brightness at min. variable; the latter confirms this fact, and thinks the phenomenon is periodic in a cycle of 21 periods. Elements not quite definitive.

7444. Disc. by Baxendell, 1863. Possibly a secondary max. near principal one. Decrease unusually rapid. 11^M pr. 3^s, 2'.7 N; $10^M.1$ foll. 12^s, 0'.1 N.

7446. Susp. by D'Arrest, 1874; conf. by Espin, Gore and Chandler.

7455. Disc. by Pogson, 1858. $8^M.5$ foll. 20^s, 7' N; 10^M pr. 15^s, 6' S.

7456. Disc. by Espin, 1888; conf. by Chandler, 1888; Yendell, 1890.

7459. Disc. by Schmidt, 1864. Period about one year, by Schmidt's obsns. Light-variations exceedingly small, and for the most part unnoticeable. Variability not sufficiently confirmed to be regarded as certain.

7468. Disc. by Goldschmidt, 1861.

7483. Disc. by Sawyer, 1885; conf. by Chandler. Elements practically but not strictly definitive.

7488. Disc. by Chandler, 1886; conf. by Sawyer. *Algol*-type. The extraordinary anomalies signalized in *A.J.* VIII, 130 and IX, 92 are explained by Dunér *A.J.* XII, 1, whose elements are adopted in the Catalogue. Dunér gives also the additional term $\pm 2^s.2$ (E-792), where upper sign is for even epochs, lower for odd. Chandler found brightness at min. to be variable, and Yendell's obsns. confirm. Light-oscillations occupy about 8 hours.

7560. Disc. at Bonn, 1858. $9^M.5$ foll. 6^s, 0'.3 N.

7571. Disc. by Peters, 1867; conf. by Parkhurst. For stars of identification see *A.N.* 109; 121.

7577. Disc. by Peters, 1872; conf. by Parkhurst. For stars of identification see *A.N.* 109; 122.

7609. Disc. by Ceraski, 1878; conf. by Knott.

7659. Disc. by Hind, 1854. 9^M pr. 5^s, 3'.9 N.

7733. Disc. by Peters, 1884; conf. by Parkhurst. Period may perhaps be 412^d, or double that of the Catalogue.

7754. Disc. by Gore, 1885; conf. by Sawyer.

7779. Disc. by Hencke, 1858. Light-curve flat at max.

7783. Susp. by Espin, 1890; proved by Yendell and Reed.

7787. Disc. by Schmidt, 1876.

7795. Disc. by Safarik, 1885, and independently by Yendell, 1892; conf. by Sawyer and Parkhurst. Yendell thinks period is about 470^d.

7803. Susp. by Hind, 1848; conf. by Argelander. Argelander's period of 432^d not borne out by Schmidt's and other obsns.

7907. Disc. by Peters, 1881; conf. by Parkhurst.

7909. Susp. by Weiss; proved by Holetschek, 1890.

7944. Disc. by Hind, 1863. 11^M pr. 13^s, 1'.5 N. R.A. of DM. is 6^s too small.

7994. Disc. by Gould, 1884.

8068. Susp. by Fleming, 1891; proved by Reed, 1893.

8073. Disc. by Goodricke, 1784. The variation of the period indicated by the elements is certain.

8093. Disc. by Gould, 1884.

8153. Disc. by Deichmüller, 1883; conf. by Chandler. Increase from 13^M to 10^M very rapid. $9^M.3$ foll. 20^s, 2'.8 N; 11^M foll. 7^s, 2'.8 N; 11^M pr. 13^s, 2'.5 N.

8230. Disc. by Argelander, 1853. Decrease from 10^M rapid. $7^M.5$ foll. 31^s, 4' N; 10^M foll. 9^s, 3' S.

8273. Disc. by Schmidt, 1847. Argelander found period 41 days; Schönfeld thinks irregular oscillations, in period of 30–50 days, more probable.

8290. Disc. by Hind, 1848. 11^M foll. 10^s, 0'.2 N; $10^M.5$ pr. 9^s, 3' N.

8373. Disc by Marth, 1864 (?). No faint stars near, and identification easy. Increase from 11^M rather slow.

8512. Disc. by Harding, 1811. Identification easy. Increase from 10^M quite rapid.

8588. Disc. by Gould, 1884.

8591. Disc. by Chandler, 1882; conf. by Yendell and Sawyer.

8597. Disc. by Peters, 1879; conf. by Parkhurst. For stars of identification, see *A.N.* 109, 123.

8600. Disc. by Pogson, 1853. 10^M pr. $0^s.5$, 0'.6 N.

LIST OF UNCONFIRMED STARS.

The following list is to a certain extent heterogeneous, and makes no pretension to completeness; that is, it by no means contains all the stars which, even in the last few years, have been alleged to be variable. It may be best described as a list of stars whose variations are plausible, at least, and therefore which require the attention of observers. No personal opinion is implied, or should be inferred, as to the variability of the stars, from the selection of these objects. There is no doubt that many of them are variable, and that some of them are not. Of the former class may be mentioned those of Gould and Sawyer, whose critical authority is not open to question. In this connection it may be mentioned that six of the variables of the *Uranometria Argentina*, excluded from the First Catalogue, merely for want of independent verification, have been since confirmed, and will be found in the preceding Catalogue.

With regard to Espin's and Fleming's stars, a watch by independent observers shows yet no trace of variation in many of them. I do not presume to account for this fact, but mention it as a justification for adhering to the rules, even while there is reason to regard the variability of many of them as highly probable. Similarly, the particularity of the evidence adduced by Roberts for several of his stars, — including apparently well-determined periods, — would seem to entitle the results of this industrious observer to confidence. The number of variables of short period announced by him. within such a limited time, is in every respect remarkable.

Observers may be embarrassed in identifying some of the stars by means of the positions here given. In many cases discordant data have been published in different places by the original observer; the differences sometimes amounting to several minutes of arc; for instance, (1018), (2141), (3055), (5174), (6275), (7139), (8499), (8594). It is hoped that this unfortunate want of care will disappear in future announcements. It has been assumed that the latest published positions are more nearly correct.

The list contains also four stars,—(1961), (6088), (6633), (7194), —which have heretofore appeared in the catalogues of known variables, but which subsequent observation has disproved, or rendered extremely doubtful.

No further explanation is needed, except that, in the column of remarks, the abbreviations Y., Pkt., R. and C., stand for Yendell, Parkhurst, Reed and Chandler.

No.	Star	1855.0		Supposed limits	Observer	Remarks
		R.A.	Decl.			
		h m s	° ′	M M		
(294)	– Cassiopeae	0 46 21	+57 46.5	8.4– 9.5	Espin	
(571)	– Ceti	1 33 0	— 7 21.6	8.4– 9.2	Safarik	Period over 4 mos.?
(691)	– Persei	1 52 6	+56 2	9.3–15	Fleming	Y. and R. do not confirm. See note
(1018)	– Horologii	2 48 12	—50 32	6.2– 9.7	Fleming	
(1220)	– Camelopardalis	3 19 53	+58 1.6	8.5–10?	Espin	
(1279)	– Camelopardalis	29 23	+62 10.4	7.3– 8.8	Fleming	Y. and R. do not confirm
(1344)	– Persei	3 41 9	+35 16.7	9– ?	Kam	C. found it invis. 1888 Apr. and Aug.
(1636)	– Reticuli	4 32 3	—63 7.4	5.8– 6.4	?	R. says period probably long
(1662)	– Caelum	35 30	—38 31	7.5–10.5	Fleming	
(1709)	– Tauri	42 20	+15 31.7	8.0– 9.4	Espin	
(1745)	(R) Eridani	48 48	—16 39.3	5.4– 6.0	Gould	S's obsns. show no change
(1772)	(S) Eridani	53 11	—12 45.1	4.7– 5.7	Gould	S's " " " "
(1801)	– Camelopardalis	55 36	+68 18.7	7.8– ?	Espin	
(1805)	– Orionis	4 58 25	+ 3 54.1	9–11.5	Boss	
(1945)	– Orionis	5 21 48	— 4 49.1	10.9–13<	Safarik	Near *S Orionis*
(1948)	31 Orionis	22 22	— 1 11.7	4.7– 6	Gould	Gore's obsns. app. conf.; Y's do not
(1961)	δ Orionis	24 36	— 0 24.6	2.2– 2.7		See note
(1988)	– Orionis	29 –	— 5 34	. .		See note
(2170)	– Leporis	5 59 47	—24 11.1	6.7– 7.5	Sawyer	Period 69^{d}. See note
(2141)	– Octantis	6 10 33	—86 25.7	7.4–<11.3	Fleming	
(2305)	– Lyncis	20 14	+58 50.6	7.5– 9	Kreutz	C. and Y. do not yet confirm
(2445)	– Monocerotis	6 45 17	— 6 58.2	8.8–10?	Espin	
(2659)	– Canis Majoris	7 21 3	—11 15.9	6.3	Espin	S., Y. and C. find star constant
(2741)	(R) Puppis	35 15	—31 19.6	6.5– 7.5	Gould	S. and C. find no certain var.
(2788)	(T) Puppis	7 43 11	—40 17.5	6.5– 7.2	Gould	
(2903)	– Cancri	8 1 16	+19 50.0	9.7– ?	Peters	Pkt. and C. cannot yet confirm
(3055)	– Carinae	28 8	—58 44.1	7.2– 8.0	Roberts	Period $6^{d}.66$. See note
(3087)	– Velorum	32 58	—46 51 3	7.5– 8.5	Roberts	Period $4^{d}.6$
(3197)	– Cancri	8 50 23	+11 23.4	8.5– 9.3?	Baxendell, jr.	
(3355)	– Carinae	9 17 53	—55 20.5	7.5– 8.5	Roberts	Period $4^{d}.38$
(3614)	(R) Velorum	10 0 42	—51 29.0	6.5– 7.5	Gould	
(3911)	– Carinae	10 51 54	—58 27.4	6.7– 8-5	Roberts	Elements, 1892 Feb. 1 + $38^{d}.6$ E
(4564)	– Muscae	12 5 1	—69 20.7	6.5– 7.3	Roberts	Elements, 1892 Jan. 3.6 + $9^{d}.66$ E
(4429)	– Crucis	15 42	—60 49.5	6.8– 8.0	Roberts	Elements, 1891 Dec. 25 + $5^{d}.827$E
(4435)	– Centauri	16 48	—48 38.2	6– ?	Pickering	
(4495)	β Corvi	26 47	—22 35.7	. .	Gould and Sawyer.	See note
(4611)	– Crucis	12 45 49	—57 38.5	6.8– 7.6	Roberts	Elements, 1892 Jan. 2.4 + 4.84 E
(4856)	– Virginis	13 26 58	—12 28.0	5.5– 6.5	Schmidt	*U.A.* obsns. confirm.; S's do not
(4905)	– Canum Venat.	13 35 29	+29 6.7	. .	Pickering	20″ S. of center of neb. G.C. 3636
(5076)	– Bootis	14 3 55	+10 30.1	8.7–12	Pogson	

No.	Star	1855.0		Supposed limits	Observer	Remarks
		R.A.	Decl.			
		h m s	° '	M M		
(5174)	– Virginis	14 20 15	+ 5 19.3	8.2–10.7	Fleming	See note
(5481)	– Librae	15 11 15	+ 2 36.9	9.5–12	Packer	See note
(5511)	– Librae	15 53	—22 24.2	8.4–<11	Fleming	
(5626)	– Librae	15 35 17	—10 27.7	7.0– 8.8	Weisse	Per. about 4 mos. C's obsns. favor
(5823)	– Normae	16 6 52	—57 32.1	6.5– 7.4	Roberts	Period 9ᵈ.75
(5949)	– Arae	27 43	—56 41.8	6.9– 8.0	Roberts	Period 4ᵈ.422
(6050)	– Scorpii	45 7	—44 51.6	7–11.4	Fleming	
(6088)	(V)Herculis	16 52 58	+35 17.4	9.5–11.7	Baxendell	Removed from Catal. See note
(6275)	– Octantis	17 6 17	—86 43.1	8.2–<11.7	Fleming	
(6470)	– Ophiuchi	17 56 7	+ 2 30.5	8.2– 8.8	Safarik	Period 58ᵈ.2
(6502)	*o* Herculis	18 1 54	+28 44.4	3.4– 3.8	Schwab	See note
(6546)	– Sagittarii	8 0	—34 9.1	6.2– 7.4	Gould	
(6633)	(V)Sagittarii	22 54	—18 21.5	7.6– 8.8	Quirling	Removed from Catal See note
(6749)	– Scuti	18 42 28	— 8 1.0	7.1– 9.5	Birmingham	C's obsns. favor
(6915)	– Sagittarii	19 9 53	—19 19.4	9.4–10.1	Safarik	Near *S Sagittarii*
(6943)	– Sagittae	15 13	+17 23.1	8.3– 9.9	Espin	Y's and C's obsns. favor somewhat
(7010)	– Sagittae	26 15	+17 26.0	6.3–<13	Chandler	See note
(7020)	– Sagittarii	27 13	—25 2.0	5.2– 6.7	Gould	S's few obsns. do not confirm
(7139)	– Sagittarii	46 54	—29 34.0	7.5–<12.6	Fleming	
(7151)	– Sagittarii	48 34	—42 13.9	8–<12.6	Fleming	
(7182)	– Cygni	55 18	+30 25.6	9– ?	Espin	
(7205)	– Cygni	19 59 6	+36 24.8	8.0– 9.2	Espin	
(7240)	– Cygni	20 4 55	+35 31.0	8.5– 9.5	Espin	
(7238)	– Cygni	5 3	+47 25.4	7.7– 8.9	Espin	C's obsns. do not confirm
(7264)	– Sagittarii	7 42	—39 33	7.7–10.7	Fleming	
(7268)	– Capricorni	8 37	—21 45.6	7.0– 7.7	Safarik	Secchi and Gore also suspect
(7280)	– Cygni	11 45	+39 54.9	5.2– 8.0	Espin	Y's obsns. do not confirm
(7279)	– Cygni	11 53	+49 29.6	8.7– 9.6	Espin	
(7302)	– Capricorni	14 28	—16 28.2	10.4–<12	Pogson	
(7351)	– Cygni	23 34	+39 29.9	7.7– 9.2	Espin	Y's obsns. do not confirm
(7194)	(R)Cephei	34 37	+88 41.0	5?–10?	Pogson	Removed from Catal. See note
(7435)	– Cygni	37 50	+46 30.1	9.2–11.5	Espin	
(7450)	– Aquarii	39 30	+ 1 54.6	8.2– 9.0	DeBall	
(7452)	– Cygni	40 15	+40 33.7	9.5–11	Espin	
(7457)	– Aquarii	40 43	— 4 35.8	8.3– 9.6	Fleming	
(7458)	– Delphini	41 4	+18 48	9?–12?	Fleming	Y's obsns. do not yet confirm
(7481)	– Cygni	45 13	+33 57.1	7.9– 9.0	Yendell	
(7502)	– Vulpeculae	20 48 24	+27 30.5	4.9– 6.4	Yendell	
(7579)	63 f_2 Cygni	21 1 37	+47 3.9	4.7– 6.0	Espin	See note
(77·4)	– Cygni	21 35 46	+53 40.0	7.5– 9.0	Espin	
(8006)	– Cephei	22 12 44	+56 15.7	8.4– 9.5	Kreutz	
(8100)	– Cephei	28 3	+55 52.6	5.8– 6.8	Yendell	
(8104)	– Aquarii	28 17	— 8 20.8	9–11.5	Hind	See note
(8106)	– Pegasi	28 48	+ 8 14.0	9.5–<13	DeBall	
(8116)	– Cephei	22 30 56	+57 40.7	7.0– 8.0	Espin	"Period probably short"
(8499)	104 Aquarii	23 34 14	—18 37.2	4.7– 5.1	Jones	Period 19ᵈ.6. See note
(8528)	19 Piscium	39 0	+ 2 40.8	4.8– 6.0	Gould	See note
(8594)	– Tucanae	50 0	—66 11	10.2–<12.6	Fleming	
(8617)	– Cassiopeae	53 54	+59 33.1	8–9 ?	Secchi	See note
(5)	– Ceti	23 58 30	—15 14.3	6.5–9	Tacubaya Observatory	

Notes to List of Unconfirmed Stars.

(691). The letter V, which at one time seemed justified (see *A.J.* XIII, 13), must be withheld for the present.

(1961). After careful consideration of all the facts, this star has been removed from the Catalogue. Neither Sawyer, Yendell, nor Chandler finds the slightest variation, so that the star, even if variable at times within the range of accidental error of obsn., must belong to that large class of similar objects, which for the present do not seem to belong properly among the recognized variables.

(1988). There are several stars in the great nebula in *Orion*, which have been strongly suspected, or alleged to be variable. Only one of these, 1986 *T Orionis*, appears yet to have been sufficiently confirmed to enter into the Catalogue. Schmidt also found evidence of var. in B 746 and B 781; but my careful watch of these in 1883-84, resulted in no certain confirmation of their var. Stone has carefully observed the region for several years, and finds probable fluctuation in 575, 589, 622 and 647. He also confirms Holden's suspicions as to 641. Stone also finds that the relative brightness of 612 and 618, and of 671 and 676, seems to be variable. But he finds 675 invariable.

(2170). The fact that Sawyer has never announced a star as variable which has not proved to be so, gives reason to regard the variability of this star as certain. But since it has not been observed by any one else, the letter must be withheld.

3055? This star cannot be certainly identified on account of diverse data given by Roberts, who identifies it with Lac. 3393 [(1855) $8^{h}\,25^{m}\,46^{s}$, $-59^{\circ}\,38'.3$], but also gives a chart putting it at about (1855) $8^{h}\,26^{m}\pm$, $-58^{\circ}\,40'\pm$. On the other hand, the identification by Pickering, *A.J.* XIII, 79, agrees with neither place, and seems improbable from the magnitude, 9, assigned in the *Cord. Z. Catal.* The singular confirmation by the H. C. O. photographs of the variation of a star apparently not the variable, is thus unaccounted for.

(4495). From Gould's and Sawyer's evidence, the var. of *β Corvi*, by a magnitude, seems certain, but it seems best to await other confirmation, in so difficult a case, before inserting it in the Catalogue.

(5174). This star, which Hartwig calls *W Bootis*, is not in *Bootes*, but in *Virgo* (see *A.J.* XIII, 13), nor has its variation been yet confirmed, to my knowledge.

(5481). Packer says two stars in 5 *M. Librae* are variable. For description and particulars, see *A.N.* 125, 157.

(6088). This star has been taken out of the Catalogue. It was inserted as *V Herculis*, in one of the *V.J.S.* ephemerides many years ago, but I know of no evidence of var. beyond a single obsn. of Baxendell. On the other hand, in a continuous watch of it for two years, and occasionally in other years, I found its light absolutely constant. Parkhurst's obsns. give equally good evidence to the same effect; and Yendell's also lead to the same conclusion.

(6502). Schwab in 1878 thought variable by $0^{M}.3$ or $0^{M}.4$, in period of 6½ days. Chandler several years previously had thought the relative difference between *o* and *ξ Herculis* to be variable. Oudemans had also noticed that the difference between *θ* and *o* was different from that assigned by Argelander's obsns. Hagen, also, thought *o* slightly var. See, too, Wolff's *Photom Unters.* and Safarik's remarks, *V.J.S.* XVII, 93.

(6633). Removed from the Catalogue for the reasons given in the note to (1961), which apply here equally.

(7010). I have given the evidence which, it seems to me, render the variability almost certain, in the *Science Observer*, Nos. 43-44, Vol. IV. It lies $0^{s}.7$ foll. north $2'.2$. DM. +17.3997. I have looked for it at least fifty times unsuccessfully, when it must have been below 13.

(7194). Removed from the Catalogue for the same reasons as given for (1961) and (6633).

(7458). Hartwig calls this star *U Delphini*. But, even if its variation be confirmed, this is a wrong designation, for there is already a star bearing this letter. See supplement to 1st Catalogue, *A.J.* no. 216.

(7579). Espin alleges as variable from 4.7 to 6.0, in long or irregular period; but my observations, some of them nearly coincident in date with his, contradict them and give no support to the idea of fluctuation. Sawyer also thinks the star is constant. It is very red and difficult to observe.

(8104). Suspected by Hind, having been estimated by him as $9^{M}.5$, but generally as 11^{M}. Argelander thought it not variable, but Schönfeld was inclined to think var. not improbable. Knott's observations in 1884 gave $11^{M}.7$. My observations too few to decide.

(8499). Jones of Haverford College observed several max. and min. giving the period $19^{d}.6$. From the place he gives, there remains a doubt whether the star observed was 103 or 104 *A Aquarii*.

(8528). Gould was inclined to suspect variability, and obsns. of Gore, Espin and Markwick seem to favor. Sawyer's and mine do not confirm, and I am strongly of the opinion that the red color is reponsible for much, if not all, of the observed contradiction in the estimates.

(8617). Secchi marked this as "var.?" My own obsns. in 1875 led me independently to suspect it, at first; but I afterwards concluded that the trouble lay entirely in the difficulty of estimating properly this very red star so close to a bluish companion.

CONTENTS.

Second Catalogue of Variable Stars, by Dr. S. C. Chandler.

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NOTE ON THE PERTURBATIONS OF *FLORA* BY *MARS* AND THE *EARTH*, AND ON BRÜNNOW'S TABLES.

By A. HALL.

The orbit of this planet lies near the inner edge of the ring of asteroids, with an inclination of six degrees to the ecliptic, and an eccentricity of 0.157. The perturbations by *Jupiter*, the great disturber of these bodies, are small. The theory of *Flora* is one of the easiest of the asteroids, and it is the first for which tables were computed. This was done by Professor Brünnow, and the tables were printed in 1855. Brünnow's elements depend on five normal places, 1848 to 1852, and in one of the normals there remains a residual of 4″.3. In 1888 the differences between computation and observation were

$$\Delta\alpha = -8^s.76\,; \qquad \Delta\delta = +51''.5$$

It is remarkable, I think, that elements and tables deduced from so short an interval should have satisfied the observations so well for nearly forty years.

These tables have another interest on account of the dispute about the theory employed by Brünnow in their construction. This dispute was carried on in a furious manner by Professors Hansen and Encke in the *Astronomische Nachrichten*, nos. 1002 to 1165.

In the *Monthly Notices*, vol. 52, no. 9, Mr. A. M. W. Downing has compared Brünnow's tables with the observations from 1865 to 1888, and has corrected the assumed elements by the method of least squares. In this way he finds large residuals in the normals, one of them amounting to 43″.9. Mr. Downing then proceeds to correct Brünnow's coefficients for the perturbations of the longitude by an empirical method, and obtains a good representation of the normals; and the corrected tables will probably satisfy the observations for some time. This method of correction appears to be similar to that adopted by Sir George Airy for the lunar theory. It assumes that all the disturbing forces have been considered, and that the coefficients of the perturbations have the right form. Brünnow computed the perturbations of the first order by *Jupiter* and *Saturn*, and I doubt if his coefficients are subject to such large corrections as Mr. Downing applies, almost wholly it will be noticed to the *Jupiter* perturbations. It is more probable, I think, that the differences from the tables are caused by disturbing forces neglected by Brünnow, and especially from the second order terms of *Jupiter*.

In order to see what terms are produced by the action of *Mars* and the *Earth*, I have computed the perturbations by these planets, using the formulas of Laplace (*Mécanique Céleste*, art. 50, Livre II). This method is not so complete as that of Hansen, and takes account of terms of the first order only with respect to the inclination and eccentricity. But it is easy of application, and for these planets terms of the higher orders which have small divisors will have long periods, and their effect will unite with the elements computed from the observations. The following are the elements used:

Flora	*Mars*	*Earth*
$m = 0$	$m' = \frac{1}{3104700}$	$m' = \frac{1}{323034}$
$n = 1086''.3382$	$n' = 1886''.6558$	$n' = 3548''.1926$
$\log a = 0.342\,694$	$\log a' = 0.182\,896$	$\log a' = 0.000\,000$
$\varphi = 9^\circ\ 0'\ 54''.4$	$\varphi' = 5^\circ\ 21'\ 4''.5$	$\varphi' = 0^\circ\ 57'\ 39''.5$

The ratios of the mean motions give,

Flora and *Mars*.

$\mu = 0.57580$	$5\mu = 2.87900$
$2\mu = 1.15160$	$6\mu = 3.45480$
$3\mu = 1.72740$	$7\mu = 4.03060$
$4\mu = 2.30320$	

The smallest divisors will occur, therefore, for

$$1 - 2\mu = -0.1516, \quad \text{and for} \quad 4 - 7\mu = -0.0306.$$

The last will be found with terms of the third order, but may produce sensible coefficients.

Flora and *Earth*.

$\mu = 0.306167$	$5\mu = 1.530835$
$2\mu = 0.612334$	$6\mu = 1.837002$
$3\mu = 0.918501$	$7\mu = 2.143169$
$4\mu = 1.224668$	

In this case the smallest divisor is of the second order, $1 - 3\mu = +0.081499$.

The following table contains the logarithms of the Laplace coefficients $b^{(i)}_{1/2}$ and their derivatives; α denoting the ratio of the mean distances.

	Flora and *Mars.*			*Flora* and *Earth*		
i	$\log b_{1/2}^{(i)}$	$\log a\,\dfrac{db_{1/2}^{(i)}}{da}$	$\log a^2\,\dfrac{d^2b_{1/2}^{(i)}}{da^2}$	$\log b_{1/2}^{(i)}$	$\log a\,\dfrac{db_{1/2}^{(i)}}{da}$	$\log a^2\,\dfrac{d^2b_{1/2}^{(i)}}{da^2}$
0	0.36896	9.99484	0.47124	0.32576	9.42699	9.62550
1	9.94198	0.15464	0.45908	9.69439	9.76969	9.53272
2	9.66925	0.10227	0.52625	9.23098	9.57563	9.75594
3	9.43658	0.01102	0.55286	8.81126	9.31948	9.69849
4	9.22272	9.90228	0.54355	8.41187	9.03819	9.56508
5	9.01980	9.78336	0.50826	8.02429	8.74318	9.38125
6	8.82424	9.65775	0.45407	7.64455	8.43950	9.16645
7	8.63377	9.52736	0.38574	7.27011	8.12983	8.93077
8	8.44712	9.39337	0 30649	6.89974	7.81578	8.68004

Denoting by l and l' the mean longitudes of *Flora* and the disturbing planet, we have the following inequalities in the longitude and radius vector.

INEQUALITIES BY *Mars.*

$$
\begin{array}{rllll}
\delta v = & +0\overset{''}{.}58\ \sin(l'-l) & -0\overset{''}{.}26\ \sin 2(l'-l) & -0\overset{''}{.}01\ \sin 3(l'-l) & \\
 & +0.09\ \sin(l'-\pi) & -0.05\ \sin(2l'-l-\pi) & & \\
 & -0.36\ \sin(2l-l'-\pi) & +0\overset{''}{.}30\ \sin(2l-l'-\pi') & & \\
 & -1.52\ \sin(3l-2l'-\pi) & +0.69\ \sin(3l-2l'-\pi') & & \\
 & +0.71\ \sin(4l-3l'-\pi) & -0.32\ \sin(4l-3l'-\pi') & & \\
 & +0.07\ \sin(5l-4l'-\pi) & -0.03\ \sin(5l-4l'-\pi') & &
\end{array}
$$

$$
\begin{array}{rllll}
\delta r = & +0.000\,000\,39 & -0.000\,001\,70\ \cos\ (l'-l) & +0.000\,001\,82\ \cos 2(l'-l) & \\
 & & +0.000\,000\,37\ \cos 3(l'-l) & +0.000\,000\,13\ \cos 4(l'-l) & \\
 & & +0.000\,000\,06\ \cos 5(l'-l) & +0.000\,000\,03\ \cos 6(l'-l) & \\
 & -0.000\,000\,41\ \cos(l'-\pi) & & -0.000\,000\,08\ \cos(l'-\pi') & \\
 & +0.000\,000\,23\ \cos(2l'-l-\pi) & & \cdot\ \cdot\qquad\cdot\ \cdot & \\
 & +0.000\,000\,03\ \cos(3l'-2l-\pi) & & \cdot\ \cdot\qquad\cdot\ \cdot & \\
 & +0.000\,001\,20\ \cos(2l-l'-\pi) & & -0.000\,001\,24\ \cos(2l-l'-\pi') & \\
 & -0.000\,004\,72\ \cos(3l-2l'-\pi) & & +0.000\,002\,01\ \cos(3l-2l'-\pi') & \\
 & +0.000\,004\,30\ \cos(4l-3l'-\pi) & & -0.000\,001\,92\ \cos(4l-3l'-\pi') & \\
 & +0.000\,000\,53\ \cos(5l-4l'-\pi) & & -0.000\,000\,24\ \cos(5l-4l'-\pi') & \\
 & +0.000\,000\,24\ \cos(6l-5l'-\pi) & & -0.000\,000\,08\ \cos(6l-5l'-\pi') & \\
 & +0.000\,000\,08\ \cos(7l-6l'-\pi) & & -0.000\,000\,04\ \cos(7l-6l'-\pi') & \\
 & +0.000\,000\,04\ \cos(8l-7l'-\pi) & & -0.000\,000\,02\ \cos(8l-7l'-\pi') &
\end{array}
$$

INEQUALITIES BY *Earth.*

$$
\begin{array}{rlll}
\delta v = & +0\overset{''}{.}26\ \sin(l'-l) & -0\overset{''}{.}02\ \sin 2(l'-l) & \\
 & -0.13\ \sin(2l-l'-\pi) & -0.10\ \sin(2l-l'-\pi') & \\
\delta r = & +0.000\,002\,71 & +0.000\,003\,44\ \cos(l'-l) & +0.000\,000\,24\ \cos 2(l'-l) \\
 & -0.000\,000\,42\ \cos(l'-\pi) & & \\
 & +0.000\,002\,37\ \cos(2l-l'-\pi) & -0.000\,000\,65\ \cos(2l-l'-\pi') & \\
 & +0.000\,000\,31\ \cos(3l-2l'-\pi) & \cdot\ \cdot & \cdot\ \cdot
\end{array}
$$

The inequalities of these planets will cause an error therefore of but a few seconds of arc in the heliocentric longitude. It is possible that terms depending on the square of the mass of *Jupiter* may become important after the lapse of twenty or thirty years; and as *Flora* is one of the asteroids that can approach near the *Earth*, or to a distance of about 0.85, and may be useful in some investigations, it would be well if the complete theory of this planet could be computed according to the method of HANSEN.

In no. 1165 of the *Astronomische Nachrichten* the accomplished Editor of that Journal has given his opinion of the dispute between HANSEN and ENCKE on the tables of BRÜNNOW. He reproaches the distinguished combatants for violating the maxim of HORACE, "*didicisse fideliter artes emollit mores, nec sinit esse feros,*" and condemns the duration and style of the contest, as well as the trifling character of the question. His opinion is in favor of ENCKE. The dispute is chiefly about the constant g, which LAPLACE adds to his integral $\int dR$, and of which he determines the value in art. 50, Livre II. This has been called "*la constante surabondante,*" or "*eine überzählige Constante*;" since it is an addition to the six constants introduced by integrating the equations of motion. Very likely it is true that the theory adopted by BRÜNNOW will produce no serious error in forty or fifty years, but the method which HANSEN gives in his "*Auseinandersetzung*" seems to me correct.

1893 *July* 1.

NOTES ON DOUBLE STARS (III),

By A. HALL.

Σ1819.

This star is an easy object to observe, but there is still some doubt about its motion. My results favor its being a binary, and indicate that the angular motion will increase.

$$\begin{aligned} s\sin p &= +0''.739 - (0''.0132)\cdot[t-1860.0] \\ &\qquad - (0''.000\,151)\cdot[t-1860.0]^2 \\ s\cos p &= +0''.954 + (0''.0224)\cdot[t-1860.0] \\ &\qquad - (0''.000\,245)\cdot[t-1860.0]^2 \end{aligned}$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1830.39	84.81	0.985	+0 981	+0.089	+0.017	−0.033
1842.37	63.44	1.079	0.965	0.482	−0.050	+0.001
1852.88	48.32	1.992	0.816	0.726	+0.009	+0.057
1864.75	31.47	1.254	0.655	1.070	+0.018	−0.016
1874.75	21.87	1.356	0.505	1.258	+0.006	−0.027
1881.26	16.23	1.430	0.400	1.369	−0.010	−0.050
1884.45	13.54	1.420	0.332	1.381	−0.006	−0.025
1886.91	11.68	1.334	+0.270	+1.306	+0.005	+0.074

Σ1888.

This fine star promises to be an interesting object, and deserves the attention of observers. The distance has diminished one-half within sixty years. and the angular motion has increased, so that after a few years we may have data for a fair determination of the orbit. The components are bright, and the observations show great differences, which may account for the large residuals in y; but a part of this result may come from the insufficiency of the assumed formula for the rapid motion in this coordinate.

$$\begin{aligned} s\sin p &= -4''.674 - (0''.000\,88)\cdot[t-1860.0] \\ &\qquad + (0''.001\,614)\,.\,[t-1860.0]^2 \\ s\cos p &= +3''.410 - (0''.127\,81)\,.\,[t-1860.0] \\ &\qquad - (0''.000\,727)\cdot[t-1860.0]^2 \end{aligned}$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1830.93	332.52	7.178	−3.312	+6.368	+0.031	+0.143
1835.43	328.88	7.070	3.654	6.053	−0.021	+0.057
1841.39	323.78	7.030	4.154	5.672	+0.058	−0.145
1847.56	318.77	6.622	4.364	4.980	−0.036	−0.093
1853.52	313.75	6.250	4.515	4.322	−0.082	−0.115
1861.99	305.27	5.651	4.614	3.263	−0.053	−0.110
1867.20	297.92	5.278	4.664	2.471	+0.071	−0.019
1873.51	287.32	4.612	4.403	1.373	+0.016	+0.174
1877.73	280.43	4.284	4.213	0.776	+0.033	+0.139
1881.46	272.32	3.986	3.983	+0.161	+0.036	+0.171
1884.45	265.40	3.710	3.698	−0.298	−0.030	+0.148
1889.96	247.54	3.296	−3.218	−0.711	−0.030	−0.361

Σ1909.

The motion of this star is very slow. and my measures of it were made for comparison with those of other observers; but the following results indicate that it is a binary. If the early observations of Herschel are correct the period is about 260 years. This star deserves attention.

$$\begin{aligned} s\sin p &= -3''.962 - (0''.034\,02)\cdot[t-1860.0] \\ &\qquad + (0''.000\,813)\cdot[t-1860.0]^2 \\ s\cos p &= -2''.411 - (0''.010\,07)\cdot[t-1860.0] \\ &\qquad + (0''.000\,498)\,.\,[t-1860.0]^2 \end{aligned}$$

Date	p	s	x	y	C—O	
					Δx	Δy
		″	″	″	″	″
1832.24	233.90	2.863	−2 313	−1.687	−0.078	−0.058
1841.77	236.17	3.863	3.209	2.151	+0.137	+0.090
1850.01	237.30	4.186	3.523	2.261	−0.018	+0.001
1862.31	238.70	4.691	4.008	2.437	−0.029	+0.006
1872.67	240.49	4.801	4.178	2.365	−0.084	−0.094
1888.61	241.58	4.896	−4.306	−2.330	+0.036	+0.061

Σ1932.

In this case the motion is nearly represented by a right line. This star needs occasional observation, and as the distance is diminishing, the character of the motion will soon be decided.

$$\begin{aligned} s\sin p &= -1''.216 + (0''.015\,37)\cdot[t-1860.0] \\ &\qquad + (0''.000\,021)\cdot[t-1860.0]^2 \\ s\cos p &= +0''.378 + (0''.009\,89)\cdot[t-1860.0] \\ &\qquad + (0''.000\,036)\cdot[t-1860.0]^2 \end{aligned}$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1830.28	273.71	1.622	−1.619	+0.105	−0.035	+0.011
1844.98	280.12	1.557	1.533	0.274	+0.091	−0.037
1852.94	282.31	1.380	1.348	0.294	+0.024	+0.016
1859.84	287.78	1.164	1.108	0.355	−0.110	+0.021
1868.20	293.56	1.192	1.093	0.476	+0.004	−0.015
1874.40	297.56	1.115	0.988	0.516	−0.003	+0.011
1879.52	302.31	1.103	0.932	0.590	+0.024	−0.005
1885.47	308.94	1.042	−0.810	+0.655	−0.001	−0.002

Σ1938.

This star is undoubtedly a binary of long period. but although 217° of apparent angle have been described. the parabolic formulas satisfy the observations fairly well. The stars passed their periastron about 1860. This system is the more interesting since it seems to be connected physically with μ' *Bootis*, distant 108″. There is a typographical error in my angle of μ', which should be 171°.42. for 1881.45.

$$\begin{aligned} s\sin p &= -0''.217 + (0''.027\,43)\cdot[t-1860.0] \\ &\qquad + (0''.000\,274)\cdot[t-1860.0]^2 \\ s\cos p &= -0''.363 - (0''.021\,35)\cdot[t-1860.0] \\ &\qquad + (0''.000\,911)\cdot[t-1860.0]^2 \end{aligned}$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1830.12	323.42	1.273	—0.759	+1.022	—0.033	+0.066
1840.19	307.64	0.857	0.679	+0.523	+0.141	—0.122
1851.13	267.41	0.469	0.469	—0.021	+0.037	—0.092
1862.68	203.88	0.507	—0.205	0.464	+0.064	+0.051
1870.24	165.65	0.596	+0.148	0.577	—0.055	+0.091
1876 87	138.61	0.696	0.460	0.522	—0.156	+0.058
1886.97	106.16	0.668	+0.642	—0.186	+0.080	—0.090

$O\Sigma$ 298.

A plot of the following coordinates of this star shows a very eccentric orbit, with a period of about 70 years. The observations should be continued.

Date	p	s	x	y
	°	″	″	″
1846.16	184.74	1.306	—0.108	—1.301
1865.81	207.71	0.898	0.418	0.795
1874.30	249.73	0.482	0.452	—0.167
1878.86	321.97	0.245	0.151	+0.193
1881.41	355.49	0.347	—0.027	+0.346
1887.50	142.13	0.393	+0.241	—0.310
1891.48	167.41	0.683	+0.149	—0.667

Σ 2021.

This easy double has been observed since the time of **Herschel**. The motion is very slow, and the observations can be nearly satisfied by a right line, but there is a little evidence that this star is a binary of long period. It needs occasional observation.

$$\begin{aligned} s\sin p &= -2''.141 + (0''.005\,95)\cdot[t-1860.0] \\ &\quad + (0''.000\,121\,3)\cdot[t-1860.0]^2 \\ s\cos p &= +2''.933 + (0''.020\,70)\cdot[t-1860.0] \\ &\quad - (0''.000\,062\,0)\cdot[t-1860.0]^2 \end{aligned}$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1832.70	316.55	3.199	—2.200	+2.322	—0.013	0.000
1842.82	318.92	3.400	2.234	2.563	+0.027	—0.004
1856.56	322.94	3.564	2.148	2.844	—0.012	+0.017
1870.02	326.71	3.739	2.052	3.126	—0.017	+0.008
1875.91	328.42	3.850	2.016	3.280	+0.001	—0.034
1882.46	329.74	3.923	1.977	3.389	+0.031	—0.022
1884.47	330.42	3.897	1.924	3.389	+0.002	+0.014
1887.48	331.46	3.908	—1.867	+3.433	—0.018	+0.022

Σ 2106.

The observations of this star are few, and rather discordant. The evidence of curvature is slight, but probably it is a binary. It should be observed, but has now become difficult from the diminution of the distance.

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$$\begin{aligned} s\sin p &= -0''.386 + (0''.001\,18)\cdot[t-1860.0] \\ &\quad + (0''.000\,037\,1)\cdot[t-1860.0]^2 \\ s\cos p &= +0''.570 - (0''.009\,89)\cdot[t-1860.0] \\ &\quad + (0''.000\,037\,8)\cdot[t-1860.0]^2 \end{aligned}$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1827.31	337.33	1.016	—0.392	+0.938	+0.007	+0.095
1843.44	332.84	0.833	0.380	0.741	—0.016	+0.003
1860.00	324.85	0.670	0.386	0.548	0.000	+0.022
1878.98	320.13	0.594	0.381	0.456	+0.030	—0.060
1885.52	314.34	0.430	—0.308	+0.301	—0.024	—0.042

Σ 2107.

This star is a binary, and should be observed.

$$\begin{aligned} s\sin p &= -0''.091 - (0''.017\,08)\cdot[t-1860.0] \\ &\quad + (0''.000\,213\,2)\cdot[t-1860.0]^2 \\ s\cos p &= -0''.885 + (0''.014\,48)\cdot[t-1860.0] \\ &\quad + (0''.000\,408\,9)\cdot[t-1860.0]^2 \end{aligned}$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1829.91	148.45	1.127	+0.590	—0.960	+0.025	+0.009
1841.18	162.49	1.113	0.335	1.061	—0.028	+0.048
1851.70	174.17	0.845	+0.086	0.841	—0.020	—0.136
1864.20	189.13	0.862	—0.137	0.851	—0.022	+0.032
1876.09	211.02	0.798	0.411	0.684	+0.100	+0.138
1880.56	224.38	0.491	0.343	0.351	—0.027	—0.063
1888.60	254.22	0.375	—0.361	—0.102	—0.044	—0.035

Σ 2120.

The motion of this star is nearly rectilinear, but my results indicate a small curvature. The observations, however, are discordant for such an easy object. Several astronomers have discussed this motion, and an ellipse has been computed in order to satisfy **Herschel**'s observation of 1783, but this observation can not be trusted for such a result. A few more observations ought to determine the character of this motion.

$$\begin{aligned} s\sin p &= -2''.602 - (0''.106\,80)\cdot[t-1860.0] \\ &\quad - (0''.000\,086\,0)\cdot[t-1860.0]^2 \\ s\cos p &= +0''.742 - (0''.105\,13)\cdot[t-1860.0] \\ &\quad - (0''.000\,138\,1)\cdot[t-1860.0]^2 \end{aligned}$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1833.25	3.64	3.445	+0.219	+3.438	—0.026	+0.017
1841.82	344.99	2.770	—0.717	2.675	+0.029	—0.068
1851.38	312.65	2.318	1.705	1.570	+0.018	+0.068
1862.68	278.80	2.960	2.925	+0.453	+0.042	+0.013
1871.24	263.82	3.718	3.696	—0.100	—0.117	—0.057
1880.56	253.03	5.113	4.890	1.492	+0.056	+0.015
1887.53	248.05	6.045	—5.607	—2.260	0.000	+0.003

COMET *b* 1893.

On the day of publication of no. 299, notices were received of the discovery at numerous places, on July 8 and 9, of a comet visible to the unaided eye in the constellation *Lynx*.

The earliest determination of position, which was received, was made by Mr. QUENISSET, at Juvisy, and telegraphed by Prof. KRUEGER to Mr. RITCHIE.

July 9.368 Greenw. M.T. $\alpha = 7^h\,50^m$, $\delta = +48°\,10'$

These facts, communicated by Mr. RITCHIE, were incorporated in a supplement to no. 299, which was inclosed with it to astronomers in this country.

Many announcements of the discovery on July 9 were received, and others were reported by the newspapers, but without observations of position.

The earliest American observation received was by Prof. BOSS, who had independently detected the comet at Albany, and as his telescope had not yet been mounted in the new observatory, determined the position by the aid of a small comet-seeker and an improvised ring-micrometer.

July 9.592 Greenw. M.T. $\alpha = 7^h\,56^m\,1^s$ $\delta = +48°\,3'$

From this position, together with another, similarly obtained the next evening, and a third, simply estimated July 11, after temporary view in a gap between clouds, Prof. BOSS at once deduced provisional elements, which with the resultant ephemeris, were distributed July 13 by Mr. RITCHIE in Special Circular no. 101 of his *Science Observer*. Prof. BOSS estimated the comet as of the brightness of a 3^M or 4^M star, with strong central condensation and a tail 4° long.

Improved elements and ephemeris were obtained by Prof. BOSS a few days later employing observations which had arrived in the meanwhile; and these were similarly distributed July 19, in *Science Observer* Circular no. 102.

Elements and ephemeris, derived from his own observations, were sent on the same day by Prof. PORTER of Cincinnati; so that notwithstanding the inevitable delay of this present number, ephemerides have been at the disposal of observers since a date long before the comet had ceased to be easily recognizable by the naked eye.

ELEMENTS AND EPHEMERIS OF COMET *b* 1893,

BY PROF. J. G. PORTER.

$T =$ July 7.4138 Berlin M.T.

$$\left.\begin{aligned} ☊ &= 337°\;\;2'.2 \\ i &= 159\;\;55.6 \\ \omega &= \;\;47\;\;\;5.2 \end{aligned}\right\}\ 1893.0$$

$$\log q = 9.82936$$

Berlin M.T.	α	δ	$\log\Delta$	Brightness
	h m	° ′		
July 19.5	11 14.0	+28 23	9.8167	0.36
21.5	11 27.2	+25 24		
July 23.5	11 37.1	+22 54	9.9049	0.23
25.5	44.6	20 50		
27.5	50.5	19 5	9.9804	0.14
29.5	55.2	17 36		
31.5	59.0	16 18	0.0443	0.09
Aug. 2.5	12 2.2	15 11		
4.5	4.9	14 12	0.0990	0.06
6.5	7.1	13 20		
8.5	9.1	+12 32	0.1459	0.05

1893 *July* 19.

ELEMENTS AND EPHEMERIS OF COMET *b* 1893.

BY REV. GEO. M. SEARLE.

The following elements have been computed from the Cambridge observations of July 10 and 11, with one made by myself at the Catholic University observatory on July 15.

$T =$ July 7.2936 Gr. M.T.

$$\left.\begin{aligned} ☊ &= 337°\;18'\;\;1'' \\ i &= 159\;\;57\;\;38 \\ \omega &= \;\;47\;\;\;7\;\;39 \end{aligned}\right\}\ 1893.0$$

$$\log q = 9.829050$$

$$\text{O—C}\qquad \Delta\lambda = -2'' \qquad \Delta\beta = -5''$$

$$\begin{aligned} x &= [9.996169]\, r \sin (v + 158°\,34'\,53'') \\ y &= [9.998466]\, r \sin (v + 247\;\;56\;\;16\;) \\ z &= [9.194797]\, r \sin (v + 305\;\;51\;\;59\;) \end{aligned}$$

1893 *July* 26.

EPHEMERIS FOR GREENWICH MIDNIGHT.

	α	δ	$\log\Delta$	Br.
	h m	° ′		
July 27	11 50.7	+19 1	9.981	0.11
29	55.4	17 32	0.014	
31	11 59.2	16 15	.045	.07
Aug. 2	12 2.4	15 8	.073	
4	5.1	14 9	.099	.05
6	7.4	13 16	.123	
8	9.4	12 29	.146	.04
10	11.2	11 46	.167	
12	12.8	11 7	.187	.03
14	14.2	10 32	.205	
16	12 15.5	+ 9 59	0.223	0.02

ELEMENTS OF COMET *b* 1893,

BY F. L. CHASE.

From heliometer observations of RORDAME's comet made here on July 10, 16 and 20, corrected for aberration and parallax, I have computed the following elements. The observation of July 10 was made by Dr. ELKIN, the other two by myself:

$$\begin{aligned} T &= 1893 \text{ July } 7.31292 \text{ Gr. M.T.} \\ \Omega &= 337^\circ\ 14'\ 29''\ \\ i &= 159\ \ 57\ \ 45 \\ \omega &= 47\ \ \ 7\ \ \ 1 \end{aligned} \Bigg\} \text{Mean Eq. 1893.0}$$

$$\log q = 9.829223$$

C—O $\Delta\lambda$ +2″ $\Delta\beta$ +2″

Yale University Observatory, 1893 *July* 27.

FILAR-MICROMETER OBSERVATIONS OF COMET *b* 1893,

MADE WITH THE 12-INCH TELESCOPE OF THE LICK OBSERVATORY,

BY R. H. TUCKER, JR.

1893 Lick Obser. M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			m s	′ ″	h m s	° ′ ″		
July 11 8 56 47	1	6	+2 9.12	. .	9 8 27.99	. .	. .	. .
9 15 21	. .	4	. .	+4 1.6	. .	44 49 10.5	9.787	0.755
9 36 1	. .	6	+2 57.12	.	9 9 15.99	. .	.	. .
12 8 53 3	2	6	—1 36.70	. .	9 35 47.92	. .	. .	. .
9 14 10	. .	6	. .	+4 39.2	. .	42 37 24.7	9.790	0.721
9 30 39	. .	8	—0 57.86	. .	9 36 26.76	. .	. .	. .
13 9 44 30	3	10	+0 4.71	. .	9 59 34.69	. .	.	
10 1 9	. .	7	. .	+5 6.2	. .	40 11 23.0	9.752	0.765
10 10 44	. .	7	+0 27.48	.	9 59 57.46	. .	. .	. .

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	9 6 18.55	+0.32	+44 45 0.7	+8.2	Weisse's Bessel IX, 56
2	9 37 24.17	+0.45	+42 32 37.6	+7.9	Weisse's Bessel IX, 749
3	9 59 29.44	+0.54	+40 6 9.4	+7.4	Weisse's Bessel IX, 1204

ELEMENTS AND EPHEMERIS OF COMET *b* 1893,

BY LEWIS BOSS.

The buildings for the Dudley Observatory upon its new site are very nearly completed, and they have been occupied for several weeks. The Observatory is to have a new equatorial telescope (aperture twelve inches) to be furnished by WARNER & SWASEY of Cleveland, the optical parts having been intrusted to Mr. JOHN A. BRASHEAR of Allegheny. This telescope has not yet been received from the makers; but is now reported to be nearly ready for mounting. At present the Dudley Observatory has no fixed instrument in position for observation.

Comet *b* has, nevertheless, been observed for position here by means of a portable telescope (focal length 1.0m., aperture 0.103m.). A common watch serves for time-piece, and its correction is ascertained from comparison with the public time-signals. Although these observations have no permanent scientific value, they have served for the computation of ephemerides. An observation, secured July 30, under favorable circumstances, results in the following position:

Gr. M.T.	App. α	App. δ	$l.\,p\Delta$	$l.\,p'\Delta$
1893 d h m s	h m s	° ′ ″		
July 30 14 8 25,	11 57 35.5	+16 48 15	9.657	0.751

Combining this with the mean of two Cambridge positions and one Cincinnati position for July 10, and the mean of two Cambridge positions for July 14, received through the courtesy of Director PICKERING, the following elements result.

$$T = 1893 \text{ July } 7.2830 \text{ Greenw. M.T.}$$

$$\begin{aligned} \omega &= 47^\circ\ \ 8'\ \ 1'' \\ \Omega &= 337\ \ 19\ \ 35 \\ i &= 159\ \ 57\ \ 50 \end{aligned} \Bigg\} 1893.0$$

$$\log q = 9.82905$$

Comparison with July 14 (C—O) : $\Delta\lambda = -4''$; $\Delta\beta = -3''$.

Previous to June 25, the comet appears to have been in a position favorable for its discovery in the Southern hemisphere. After that time, its position and theoretical brightness should have rendered it easy of detection in the morning hours from this hemisphere, — as will appear from the following computed positions:

Gr. M.T.	R.A.	Decl.	Br.
	h m s	° ′	
1893 June 30.5	3 44 48	+32 38	0.42
July 4.5	4 58 1	+42 25	0.66
8.5	7 13 49	+48 28	1.02

On July 9, from comparison with *ι Ursae Majoris* and other stars, I estimated the brightness of the comet to have been about equivalent to $3^M.5$. August 2, in a fine sky, using the telescope with the eye-piece drawn slightly out of focus, the equivalent light of the comet was estimated to be about one-quarter of the interval from DM. 15°2445 to DM. 15°2436 brighter than the former, or $6^M.5$. The theoretical diminution of magnitude from July 9 to August 2 is $3^M.1$. Owing to the low altitude of the comet on the former date it is quite possible that its brightness was underestimated.

Toward the end of November next the comet will be in a position favorable for observation in the morning. Theoretically it should then be $4^M.2$ fainter than it was on August 2. and fully $11^M.0$. Even if it prove somewhat fainter than this it may still be possible to observe it.

Ephemeris for Greenwich Midnight.

Gr. M.T.	App. α	App. δ	log Δ	Br.
	h m s	° ′ ″		
Aug. 9.5	12 10 21.3	+12 6 20	0.1570	0.032
10	11 12.9	11 45 33	0.1673	
11	12 1.9	11 25 43	0.1773	
12	12 48.3	11 6 46	0.1870	
13	13 32.6	10 48 37	0.1963	0.024
14	14 14.9	10 31 12	0.2053	
15	14 55.4	10 14 29	0.2141	
16	15 34.4	9 58 24	0.2225	
17	16 12.0	9 42 55	0.2307	0.018
18	16 48.5	9 27 59	0.2387	
19	17 23.8	9 13 35	0.2464	
20	17 58.1	8 59 39	0.2539	
21	18 31.4	8 46 10	0.2611	0.014
22	19 3.9	8 33 7	0.2681	
23	19 35.7	8 20 28	0.2750	
24	20 6.8	8 8 11	0.2816	
25	20 37.3	7 56 16	0.2880	0.012
26	21 7.2	7 44 40	0.2943	
27	21 36.7	7 33 23	0.3003	
28	22 5.9	7 22 23	0.3062	
29	22 34.7	7 11 40	0.3120	0.009
Oct. 30	45 5	+0 45	0.4706	0.002
Nov. 30.5	12 45 49	—0 10	0.4654	0.001

Brightness July 9.5 = 1.0

Heliocentric Coordinates.

$$x = [9.996179]r\ \sin(158^\circ\ 33'\ 46''.3+v)$$
$$y = [9.998464]r\ \sin(247\ 55\ 12.7+v)$$
$$z = [9.194414]r\ \sin(305\ 48\ 55.7+v)$$

OBSERVATIONS OF COMETS,

MADE AT THE CINCINNATI OBSERVATORY,

By J. G. PORTER.

1893 Cincinnati M.T.		*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
				Comet 1892 VI.					
	h m s			m s	′ ″	h m s	° ′ ″		
July 1	9 47 36	1	8,8	+2 15.57	—2 38.2	17 12 17.85	—21 46 45.6	n8.965	0.885
2	9 17 14	1	8.8	+1 27.76	+3 56.8	17 11 30.04	—21 40 10.6	n9.164	0.880
5	9 26 17	2	4,4	+2 55.16	+7 50.3	17 9 12.99	—21 20 52.2	n8.988	0.882
	9 26 17	3	7,7	+0 27.43	—5 59.8	17 9 12.96	—21 20 55.8	n8.988	0.882
9	9 13 27	4	5,5	+0 33.68	—5 7.4	17 6 34.13	—20 56 50.8	n8.931	0.881
	9 13 27	5	6,6	—0 30.04	+5 33.0	17 6 33.98	—20 56 59.3	n8.931	0.881
				Comet 1886 VII = α 1893 (Finlay).					
June 25	14 29 20	6	8,8	—1 17.58	+0 18.5	2 36 37.31	+12 50 32.0	n9.672	0.728
July 10	14 31 58	7	10,10	+0 56.11	—6 51.0	3 17 10.87	+18 9 57.0	n9.683	0.721
	14 31 58	8	4,4	—1 36.96	+6 4.9	3 47 10.88	+18 10 1.1	n9.683	0.721
14	15 2 11	9	10,10	—0 59.09	—0 6.6	4 5 37.02	+19 15 54.4	n9.682	0.691
18	14 49 56	10	8,8	—0 33.31	—6 13.2	4 23 35.74	+20 12 43.6	n9.688	0.703
22	14 54 17	11	8,8	+1 37.61	—2 50.5	4 11 15.70	+21 1 23.2	n9.690	0.698
	14 54 17	12	8.8	+1 17.82	+3 6.3	4 11 16.02	+21 1 25.7	n9.690	0.698
				Comet *b* 1893.					
July 10	8 58 3	13	12,12	—0 27.99	+ 2 24.0	8 33 2.40	+46 50 58.9	9.782	0.775
11	9 4 20	14	8.8	—3 14.77	— 5 57.4	9 5 31.91	+45 2 41.1	9.786	0.747
13	8 57 2	15	6,6	+3 25.32	—14 17.1	9 56 41.49	+40 32 27.6	9.777	0.680

1893 Cincinnati M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			Δα	Δδ	α	δ	for α	for δ
Comet *b* 1893. — Cont.								
July 13 8h 57m 2s	16	6.6	—2m 37s.11	+ 9′ 6″.0	9h 56m 41s.31	+40° 32′ 35″.2	9.777	0.680
16 8 33 17	17	11.11	—0 14.29	+ 7 8.0	10 45 51.83	+33 44 2.8	9.737	0.612
19 10 12 26	18	6.6	+0 1.47	— 2 13.2	11 15 31.17	+28 2 22.6	9.705	0.748
21 8 33 25	19	8.8	—0 31.98	+ 1 0.6	11 27 57.08	+25 11 33.1	9.692	0.637
10 11 6	20	3.3	+1 19.69	+10 57.1	11 28 20.10	+25 5 55.6	9.696	0.749
10 14 6	21	4.4	+1 8.40	—13 14.5	11 28 20.30	+25 5 47.5	9.696	0.749
23 9 3 4	22	4,4	+1 11.26	— 5 56.1	11 37 43.95	+22 42 28.6	9.693	0.683
9 3 4	23	4.4	—1 21.29	— 1 2.0	11 37 43.85	+22 42 29.2	9.693	0.683
26 8 22 26	24	10.10	—0 39.35	— 2 49.9	11 48 9.78	+19 46 48.0	9.669	0.660

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	17h 9m 59s.63	+2s.65	—21° 43′ 56″.7	—10″.7	Cinc. Proper-motion Cat. 979
2	17 6 15.21	+2.62	—21 28 31.6	—10.9	Weiss-Arg. 13154 ; Cinc. Z. 2816
3	17 8 42.90	+2.63	—21 14 45.2	—10.8	Weiss-Arg. 13193 ; Cinc. Z. 2821
4	17 5 57.84	+2.61	—20 51 32.6	—10.8	Eq. comp. with Weiss-Arg. 13188, Yar. 7266,
5	17 7 1.40	+2.62	—21 2 21.6	—10.7	Cinc. Mer. Cir. [Cinc.Z. 2818
6	2 37 54.67	+0.22	+12 50 6.4	+7.1	Yar. 1233 ; Glas. 1, 619 ; Glas. 2, 222
7	3 46 14.37	+0.39	+18 16 39.4	+8.6	Weisse-Bessel III, 969 ; Rüm. 2, 1978
8	3 48 47.46	+0.38	+18 3 47.6	+8.6	Wien 1861, 29
9	4 6 35.65	+0.46	+19 15 52.1	+8.9	Weisse-Bessel IV, 66-7 ; Rüm. 2, 2165
10	4 24 8.55	+0.50	+20 18 47.7	+9.1	Eq.comp. with Berlin A.G.Z. and W.B.IV,492
11	4 39 37.54	+0.55	+21 4 4.6	+9.1	Berlin A.G.Z.
12	4 39 57.65	+0.55	+20 58 10.3	+9.1	Berlin A.G.Z.
13	8 33 30.21	+0.18	+46 48 27.2	+7.7	Oe.Arg. 9189-90
14	9 8 46.35	+0.33	+45 8 30.3	+8.2	Oe.Arg. 9733 [Paris 12390. Bonn 41°.2046
15	9 53 15.65	+0.52	+40 46 37.3	+7.4	W.B. IX,1084, & eq. comp. with Brux. 4199.
16	9 59 17.87	+0.55	+40 23 21.8	+7.4	Olmütz ring-micr. & eq.comp. with same stars
17	10 46 5.41	+0.71	+33 36 49.2	+5.6	Leiden A.G. Zones
18	11 15 28.93	+0.77	+28 4 31.8	+4.0	Weisse-Bessel XI, 241
19	11 28 28.28	+0 78	+25 10 29.5	+3.0	Equat. comp. with next two stars
20	11 26 59.64	+0.77	+24 54 55.5	+3.0	Paris 14089, Berlin A.G.Z.
21	11 27 11.13	+0.77	+25 18 59.0	+3.0	Weisse-Bessel XI, 469
22	11 36 31.89	+0.80	+22 48 22.6	+2.1	Berlin A.G.Z.
23	11 39 4.34	+0.80	+22 43 29.1	+2.1	Bonn VI, +22°2398
24	11 48 48.32	+0.81	+19 49 36.9	+1.0	Bonn VI, +20°2657

NEW ASTEROIDS.

Prof. Krueger has communicated the discovery of two asteroids by Mr. Charlois:

					α	δ	Daily Motion
1893	*AC*	12M	July 14,	12h 48m.6 Nice M.T.	20h 42m 1s.0	—15° 31′ 42″	—60s in α, and 1′ northward.
	AD	11M	16,	10 33.6 " "	20 8 48.8	—17 6 41	—56s " " 0′ in decl.

Also one by Borrelly.

					α	δ
	AE	12M	July 5.	10h 19m 31s Marseilles M.T.	17 23 52.90	—21 39 10.4
			6,	9 30 46 " "	17 23 4.52	—21 43 24.8

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New Asteroids.

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NOTES ON DOUBLE STARS (IV),

BY A. HALL.

ξ *Scorpii* = Σ1998.

The stars A and B of this triple system are of the fifth magnitude, and have a period of 105 years. The star C is of the seventh magnitude, and has a very slow motion. Its period is uncertain. This system appears to be similar to that of ζ *Cancri*. Dr. SCHORR has recently investigated the motions of these stars, but the evidence for a fourth disturbing body is not conclusive. This system needs a long and careful series of observations. I have compared my observations with Dr. SCHORR's elements of A and B, and with his interpolation-formula for C. The results are as follows:

A AND B. $\frac{AB}{2}$ AND C.

Date	p	s	C—O		p	s	C—O	
			Δp	Δs			Δp	Δs
	°	″	°	″	°	″	°	″
1882.46	12.74	1.116	—0.28	+0.148	66.33	7.263	+0.15	+0.007
1883.51	13.90	1.380	0.00	—0.114	67.00	7.315	—0.74	— 0.023
1884.50	14.60	1.278	+0.74	—0.014	64.35	7.260	+1.70	+0.042
1886.57	17.97	1.070	+0.22	+0.174	65.47	7.307	+0.17	+0.026
1888.56	20.65	0.960	+0.51	+0.248	65.30	7.165	—0.05	+0.200

Σ2281.

The anomaly in the relative positions of these stars about 1865 is due, I think, to errors of observation, which happen to be large at that time. My results show that this star is a binary of long period.

$$s \sin p = -1''.230 + (0''.01384) \cdot [t-1860.0] + (0''.0001832) \cdot [t-1860.0]^2$$

$$s \cos p = -0''.386 - (0.00063) \cdot [t-1860.0] + (0''.0001091) \cdot [t-1860.0]^2$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1831.05	259.57	1.543	—1.518	—0.279	+0.041	+0.002
1842.11	255.98	1.407	1.365	0.341	—0.054	+0.001
1854.65	253.90	1.305	1.254	0.362	—0.045	—0.018
1868.00	250.63	1.244	1.174	0.413	+0.067	+0.029
1877.39	250.42	1.035	0.975	0.347	+0.041	—0.017
1885.59	245.05	0.788	—0.714	—0.332	—0.042	+0.001

Σ2454.

The angular motion of this has become very small, while the distance remains nearly constant. The observations are nearly satisfied by a rectilinear motion.

$$s \sin p = -0''.526 - (0''.00740) \cdot [t-1860.0] + (0''.0000787) \cdot [t-1860.0]^2$$

$$s \cos p = -0''.577 + (0''.00361) \cdot [t-1860.0] + (0''.0000409) \cdot [t-1860.0]^2$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1831.50	203.79	0.753	—0.304	—0.689	+0.053	+0.042
1843.76	208.00	0.600	0.282	0.530	—0.103	—0.095
1861.45	221.46	0.855	0.566	0.641	+0.029	+0.069
1874.34	233.02	0.857	0.685	0.516	+0.069	—0.001
1884.67	233.95	0.757	—0.612	—0.446	—0.049	—0.017

Σ2455.

This star has been referred to as exhibiting a case of rectilinear motion, but my results indicate that it is a binary.

$$s \sin p = +3''.178 + (0''.00823) \cdot [t-1860.0] - (0''.0000305) \cdot [t-1860.0]^2$$

$$s \cos p = -1''.797 + (0''.06107) \cdot [t-1860.0]. - (0''.0003002) \cdot [t-1860.0]^2$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1828.77	144·29	4.927	+2.876	—4.001	+0.015	+0.004
1853.26	124·52	3.862	3.182	2.189	—0.060	—0.034
1865.85	114·41	3.550	3.233	1.467	—0.008	+0.017
1875.17	106·82	3.337	3.194	0.966	+0.102	+0.026
1884.62	97·64	3.453	+3.422	—0.459	—0.059	—0.016

δ *Cygni* = Σ 2579.

This star is difficult of observation, since the small companion is frequently hidden in the rays of the bright star, but I found it an easy object in the twilight. It is probably a binary of long period.

$$\begin{aligned} s\sin p &= -0''.016 - (0''.03740)\cdot[t-1860.0] \\ &\quad + (0''.000\,020\,5)\cdot[t-1860.0]^2 \\ s\cos p &= +1''.575 - (0''.005\,15)\cdot[t-1860.0] \\ &\quad - (0''.000\,394\,8)\cdot[t-1860.0]^2 \end{aligned}$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1830.21	37.67	1.785	+1.091	+1.413	+0.025	—0.035
1842.29	24.02	1.660	0.676	1.516	—0.024	+0.026
1852.13	12.31	1.543	+0.329	1.508	—0.050	+0.084
1861.69	355.91	1.630	—0.116	1.626	+0.037	—0.061
1869.37	346.37	1.534	0.361	1.491	—0.003	+0.001
1879 04	331.22	1.596	0.768	1.399	+0.046	—0.036
1889.63	313.77	1.486	—1.073	+1.208	—0.033	+0.047

Σ 2708.

These stars appear to present a case of pure rectilinear motion, and they will therefore continue to separate. As a double star they have no further interest, except for the relative proper motion. According to my formulas these stars were at a minimum distance in 1797.

$$\begin{aligned} s\sin p &= -\ 6''.486 - (0''.176\,33)\cdot[t-1860.0] \\ s\cos p &= +16''.275 + (0''.189\,64)\cdot[t-1860.0] \end{aligned}$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1832.63	351.57	11.252	— 1.650	+11.130	—0.010	—0.045
1840.76	346.05	13.082	3.154	12.697	+0.061	—0.071
1853.70	340.43	15.952	5.343	15.030	—0.032	+0.050
1866.34	336.48	18.858	7.526	17.291	—0.078	+0.186
1877.25	333.90	21.732	9.561	19.516	+0.033	+0.030
1886.36	332.49	24.155	—11.157	+21.424	+0.023	—0.150

λ *Cygni* = OΣ 413.

This star is a binary, and it needs to be observed with more care. The observations are discordant.

$$\begin{aligned} s\sin p &= +0''.588 + (0''.002\,92)\cdot[t-1860.0] \\ &\quad - (0''.000\,017\,5)\cdot[t-1860.0]^2 \\ s\cos p &= -0''.069 + (0''.011\,94)\cdot[t-1860.0] \\ &\quad - (0''.000\,147\,8)\cdot[t-1860.0]^2 \end{aligned}$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1843.86	120.22	0.630	+0.544	—0.317	—0.008	+0.016
1852.39	104.44	0.570	0.552	0.142	+0.013	—0.027
1863.00	93.09	0.600	0.599	—0.032	—0.002	—0.002
1876.20	84.60	0.642	0.639	+0.060	—0.009	+0.025
1886.76	76.43	0.668	+0.649	+0.159	+0.004	—0.012

ζ *Aquarii* = Σ 2909.

This is one of the oldest of the double stars, having been observed by Christian Mayer in 1777. The brightness of the components has introduced large personal errors, especially in the distance, when they sometimes amount to 1″, or to nearly one-third of the quantity measured. The orbits that have been computed must be very uncertain, and all that can be said is that this star is probably a binary of very long period.

$$\begin{aligned} s\sin p &= -1''.079 - (0''.02797)\cdot[t-1860.0] \\ &\quad + (0''.000\,020\,5)\cdot[t-1860.0]^2 \\ s\cos p &= +3''.259 - (0''.013\,13)\cdot[t-1860.0] \\ &\quad - (0''.000\,116\,6)\cdot[t-1860.0]^2 \end{aligned}$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1825.73	359.72	3.600	—0.018	+3.600	—0.078	+0.072
1832.81	355.22	3.458	0.288	3.446	—0.016	+0.084
1838.26	350.95	3.638	0.574	3.592	+0.113	—0.103
1845.60	347.95	3.455	0.721	3.379	+0.039	+0.045
1851.17	345.11	3.488	0.896	3.371	—0.019	—0.039
1864.75	338.76	3.314	1.201	3.089	—0.011	+0.105
1877.16	334.88	3.453	1.466	3.126	—0.087	—0.126
1888.78	324.97	3.340	—1.917	+2.735	+0.050	+0.049

π *Cephei* = OΣ 489.

The inequality of the components makes the observations of this star uncertain, and hence the results are rather doubtful. But a curvature of the orbit is indicated, and the star is probably a binary.

$$\begin{aligned} s\sin p &= +0''.154 + (0''.021\,656)\cdot[t-1860.0] \\ &\quad - (0''.000\,178\,8)\cdot[t-1860.0]^2 \\ s\cos p &= +1''.275 + (0''.002\,535)\cdot[t-1860.0] \\ &\quad - (0''.000\,440\,6]\cdot[t-1860.0]^2 \end{aligned}$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	″	″	″	″	″
1846.48	351.38	1.150	—0.172	+1.137	0.000	+0.091
1851.42	358.46	1.215	—0.033	1.215	—0.012	+0.050
1868.05	15.34	1.267	+0.266	1.222	+0.050	+0.004
1877.53	26.05	1.251	0.549	1.124	—0.070	—0.028
1885.89	27.53	1.224	+0.546	+1.085	+0.029	—0.171

Σ 3050.

In this case the motion is very slow, and the data are not sufficient to determine whether the star is binary or not, but the chances are that it is a binary. The diminution of the distance makes it probable that the angular motion will soon increase.

$$\begin{aligned} s\sin p &= -1''.038 - (0''.009\,43)\cdot[t-1860.0] \\ &\quad + (0''.000\,066\,0)\cdot[t-1860.0]^2 \\ s\cos p &= -3''.203 + (0''.023\,74)\cdot[t-1860.0] \\ &\quad + (0''.000\,103\,5)\cdot[t-1860.0]^2 \end{aligned}$$

Date	p	s	x	y	C—O	
					Δx	Δy
	°	"	"	"	"	"
1832.65	191.02	3.780	—0.722	—3.710	—0.009	—0.065
1849.37	195.06	3.674	0.955	3.548	+0.024	+0.105
1861.99	199.61	3.174	1.065	2.990	—0.018	—0.092
1876.30	202.77	3.030	1.173	2.794	—0.001	+0.005
1887.92	206.86	2.775	— 1.254	—2.476	+0.004	+0.017

These stars, with those given in nos. 265, 269 and 301, except a few omitted for slowness of motion, complete the list which I marked for discussion of this kind two years ago, on closing my observations. Nearly all of them have proved worthy of the notice of observers, and I hope some astronomer who has the instrumental means will put them on his working list. Some of them which promise to be rapid binaries should be observed every year, and others at longer intervals. In almost every discussion of the motions of double stars the need is felt of accurate, and more, observations before we can know much about these motions.

1893 *August* 7.

In the preceding discussion, my purpose being chiefly to call the attention of observers to those stars, I have omitted criticism of certain cases where the law of areas is not satisfied by the observations. This will be a question for the future. There may also be cases in nearly rectilinear motion when the direction of curvature does not accord with the common law of attraction, and since such a result might arise from discordant observations I have given it no attention.

It was my intention to compute orbits of η *Coronae Borealis*, and 70 *Ophiuchi*. The first is one of the few double stars for which we have at present sufficient data for a good orbit, but I learn that a German astronomer has undertaken this work. The orbit of 70 *Ophiuchi* has hitherto been uncertain, on account of the small coefficient of the distance from the node to the periastron, in the equations of condition; so that the orbit carefully computed by Dr. Schur is now largely in error. I hope my observations, 1880 to 1891, will help remove this indetermination. Mr. Ristlen has undertaken this orbit, and must have it nearly finished.

OBSERVED MAXIMA AND MINIMA OF VARIABLE STARS, 1892–93.

By PAUL S. YENDELL.

107. *T Cassiopeae.*

Eleven observations, from 1893 Jan. 21 to April 9, of *T Cassiopeae*, indicate a maximum of $7^{M}.8$, 1893 Feb. 23.5.

432. *S Cassiopeae.*

This star was observed from 1893 Jan. 21 until April 9, twelve observations being secured; a maximum at $8^{M}.5$ is indicated to have taken place Feb. 22.5.

678. *U Persei.*

Since the confirmation of the variability of this star, published in no. 279 of this Journal, I have kept it as constantly under observation as possible. From 1892 Oct. 19 to Nov. 24, it declined from $9^{M}.7$, until on the latter date it was estimated to be $11^{M}.0$: when next looked for, Dec. 5, it was invisible, as also Dec. 7; it was just held in a very clear sky, when nearly overhead, and its magnitude estimated as $12^{M}.0$, on Dec. 9; it was next seen, and estimated at $11^{M}.5$ on 1893 Jan. 20. From this date it rose steadily to $8^{M}.1$, which it reached 1893 March 31; a careful consideration of the curves of decrease and increase seems to imply that a minimum, not fainter than $13^{M}.0$, took place about 1893 Jan. 1: on April 4 it was estimated at $8^{M}.3$, at which brightness it remained until May 6, when its approach to the northwest horizon put a stop to observations. It was next seen July 21, and estimated — rather uncertainly, from a single-star comparison—at $7^{M}.8$; an observation on Aug. 5, using two comparison-stars, gives a light of $8^{M}.2$. It seems probable that the actual maximum took place about July 15.

The star shows a redness of 6.4 of Chandler's scale.

1717. *V Tauri.*

A series of eight observations of *V Tauri* was obtained between 1893 Jan. 17 and April 9, and shows a maximum of about 9^{M} on March 13.

1981. *S Camelopardalis.*

Observations of this star have been kept up as continuously as possible since the minimum published in No. 290 of this Journal. The star's light increased, with some fluctuations, to a maximum of $8^{M}.5$, which was observed on 1893 May 24; from this point it fell off until June 10, when it was estimated at $8^{M}.8$. Observations were interrupted from this date until July 31, when it was found $8^{M}.8$. It seems probable that the actual maximum occurred on May 24, and this is confirmed by a later observation of $9^{M}.3$ on Aug. 5.

2013. *U Aurigae.*

A watch was begun for this new variable on 1892 Oct. 18, but it was not seen until 1893 March 12. Its rise must have been rapid, as when looked for on February 11, it was certainly below $11^{M}.5$, being invisible with my telescope, while when seen on March 12, its light was estimated at $9^{M}.1$. From this date it increased steadily until March 27, reaching $8^{M}.6$, at which brightness it continued until April 9: from the latter date it fell away rapidly, its light when last observed on May 10, being about $9^{M}.7$. The plotted curve indicates a maximum on April 4. The star is quite red, being estimated, from nine comparisons, at 7.5 of Chandler's scale.

2279. *T Monocerotis.*

This star was observed forty-five times from 1892 Nov. 11 to 1893 April 9. From these observations, though much interrupted by weather and moonlight, I deduced six maxima and three minima, as follows:

Maxima	w	Minima	w
1892 Nov. 14.47	4	1892 Dec. 24.90	3
Dec. 10.46	4	1893 Jan. 21.80	4
1893 Jan. 5.81	3	Mar. 17.30	3
Feb. 3.50	2		
Mar. 1.74	4		
29.76	4		

2528. *R Geminorum.*

Observations on this star were begun on 1893 April 16, when it was found at $10^{M}.5$; it increased rapidly to $7^{M}.8$, which it reached May 6; observations were continued until stopped by the twilight, the last being May 22, when the star had decreased to $8^{M}.0$. The observations, as plotted show a maximum on May 14, but it is uncertain, in view of the small number of observations afterward obtained, whether it is a real maximum, or only a marked inflection in the curve of the star's increase.

2742. *S Geminorum.*

This star was observed, from 1893 Jan. 16 to May 10, seventeen times. A principal maximum of $8^{M}.3$ on Feb. 28, and a secondary one of $8^{M}.4$ on March 18, are indicated, the star having decreased to $8^{M}.9$ on March 11; when last observed it had fallen to $10^{M}.0$.

2780. *T Geminorum.*

Fourteen observations of this star, from 1893 Jan. 16 to April 9, indicate that a maximum of $8^{M}.6$ was passed Feb. 22; when last observed, the star's light was estimated at 11^{M}.

3890. *W Leonis.*

A maximum of *W Leonis* is indicated on 1893 April 12, at $9^{M}.5$; an observation on May 18, $9^{M}.6$, seems to give some indication of a secondary maximum; but this is not very certain, there being some doubt as to the identification of the comparison-star employed on that date. I have seven observations in all, from 1893 March 18 to June 10.

4805. *W Virginis.*

Observations of *W Virginis* were badly broken up this year, by the weather, only twenty-one being obtained, from 1893 March 12 to July 18. These observations yield, upon the application of a mean light-curve, four maxima and two minima, as follows:

Maxima	w	Minima	w
1893 May 2.08	3	1893 April 8.69	2
June 6.18	3	May 11.10	3
21.96	2		
July 11.89	3		

4940. *W Hydrae.*

I watched this star from 1893 April 11 to June 1, securing fifteen observations; these indicate a well-marked maximum of $6^{M}.7$ on May 7. The star is very red, three observations showing a coloration of 8.2 of CHANDLER's scale.

4847. *S Virginis.*

I have twenty-three observations of *S Virginis*, extending from 1893 March 12 to July 16. At the first observation, its light was estimated to be $8^{M}.9$, from which it increased steadily to $7^{M}.3$, which light it reached on April 9; the curve at maximum was very flat, no certain decrease being observed for a month, after which the star fell slowly away until June 18, at which point it began to diminish more rapidly, having dropped to $8^{M}.3$ when last observed.

The plotted curve indicates a maximum 1893 April 20.

5762. *X Herculis.*

My observations of *X Herculis* since the last published maximum (*A.J.* 276) show a bright and ill-defined minimum about 1892 Aug. 24, not going below $6^{M}.5$; a maximum of $5^{M}.9$, 1892 Sept. 17 ±; and a minimum of $6^{M}.8$, 1893 May 8.

5830. *R Scorpii.*

I secured three observations of *R Scorpii* at its recent maximum, as follows: 1893 May 20, estimated $11^{M}.0\pm$, no available comparison-star; May 24, $10^{M}.5$, w. 2; June 4, not seen, limit $<11^{M}.5$. These would seem to imply that the maximum took place about May 24.

8594. *V Cephei.*

Since the maxima of this star published in this Journal, no. 258, it has passed a minimum of $6^{M}.8$, 1892 July 3, and a maximum of $6^{M}.3$, 1893 Feb. 3, and is now at or near a minimum. The star's changes are so slow, that it is very difficult to fix exactly the dates of the phases, especially the minima.

Dorchester, 1893 *August* 8.

OBSERVATIONS OF COMET *b* 1893,

MADE WITH THE 16-INCH EQUATORIAL AND FILAR-MICROMETER OF GOODSELL OBSERVATORY, NORTHFIELD, MINN.,

BY DR. H. C. WILSON.

[Communicated by WM. W. PAYNE, Director]

1893 Northfield M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
h m s			m s	′ ″	h m s	° ′ ″		
July 11 11 5 40	1	6 , 4	+2 28.16	+ 4 13.1	9 8 47.13	+44 49 24.4	9.580	0.892
12 10 32 30	2	6 . 5	—1 52.02	+ 8 0.2	9 35 32.73	+42 40 46.8	9.669	0.847
13 8 56 51	3	6 , 4	—2 5.82	+ 5 31.3	9 57 12.59	+40 29 0.4	9.740	0.716
8 56 51	4	6 , 4	—3 27.84	+ 0 31.1	. . . .	. . . .	9.740	0.716
14 9 39 41	5	6 . 4	+5 7.00	— 0 12.5	10 17 11.85	+38 2 30.7	9.728	0.675
17 9 54 48	6	6 , 4	—1 51.74	— 6 57.4	10 58 5.32	+31 33 13.7	9.687	0.767
9 54 48	7	6 , 4	—2 47.14	+ 2 30.0	10 58 5.50	+31 33 9.5	9.687	0.767
21 9 11 35	8	9 , 4	+1 58.92	+13 13.0	11 28 14.06	+25 7 23.2	9.667	0.731
24 9 27 00	9	9 , 4	—1 29.02	+ 8 2.2	11 41 50.15	+21 35 53.7	9.656	0.756
9 29 21	10	3 , 2	—5 47.40	— 0 30.1	11 41 50.70	+21 35 50.7	9.656	0.758

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	9 6 18.76	+0.31	+44 45 3.1	+8.2	Oe. Argel. N. 9690
2	9 37 24.34	+0.45	+42 32 38.8	+7.8	Lal. 19043, 44 ; Weisse's Bessel IX. 749
3	9 59 17.87	+0.55	+40 23 21.7	+7.4	Olmütz ring-microm. ; Cincin. filar-microm.
4	10 0 40	+0.55	+40 18	+7.4	DM. 40°2289
5	10 12 4.26	+0.59	+38 2 36.3	+6.9	Yarnall 4376
6	10 59 56.31	+0.75	+31 40 6.2	+4.9	Bonn VI, 31°2232
7	11 0 51.89	+0.75	+31 30 34.6	+4.9	Leiden A.G.Z. 27, 37 ; 166, 149
8	11 26 14.37	+0.77	+24 54 7.2	+3.0	Armagh, 1330 ; Bonn VI. 25°2388
9	11 43 18.37	+0.80	+21 27 49.8	+1.7	Berlin A.G.Z. 235, 19 ; 246, 50
10	11 47 37.28	+0.82	+21 36 19.2	+1.6	Microm. comparison with Bonn VI. 21°2370

RESEARCHES UPON COMET 1889 V,

BY CHARLES LANE POOR.

Several papers have appeared in which was discussed the action of *Jupiter* upon Comet 1889 V (BROOKS). For these, radically different periods were given for the comet before it entered the sphere of *Jupiter's* activity, in 1886. In Dr. CHANDLER's original paper (*Astronomical Journal*, no. 205), the period of the comet in 1886 was given as twenty-six and a half (26.5) years. This result, however, depended upon the observations of only about three months. In *A.J.* no. 228, I gave the period as deduced from an orbit that included observations of over eight months; this period was twenty-nine (29) years. In both of these results only the principal perturbations were taken into account, the entire disturbance being considered as taking place during the few months of closest approach. In a later number of the Journal, no. 244, I gave the results obtained by taking account of the action of *Jupiter* during the entire interval between the time of appulse and that of the comet's appearance. The orbit on which this work was based was, however, not definitive, being obtained, by the method of variation of geocentric distances, from ten normal places between July 1889 and December 1890. This work gave a period of over forty (40) years for the comet before 1886.

As the interest in this problem was very much increased by the great probability of the comet's identity with that of LEXELL, 1770, as was first pointed out by Dr. CHANDLER, I determined to re-investigate the character of the appulse, and to do the work in as thorough a manner as possible. I was greatly aided in the undertaking by the appearance of a definitive orbit of the comet, computed in a most careful and painstaking manner by Dr. JULIUS BAUSCHINGER. This work is entitled "*Untersuchungen über den periodischen Kometen* 1889 V (BROOKS)." *I Theil.* So complete was this investigation of the orbit, that it seemed utterly useless to attempt to improve upon it; I therefore made it the basis of my work.

Unfortunately, however, Dr. BAUSCHINGER finds a direct solution of his normal equations impossible; the last element determined being very uncertain. He, therefore, as is usual in such cases, determines the remaining elements as functions of this one, $\Delta M°$, whose value is subsequently found by substitution in the original equations of condition. His final elements are then still subject to an uncertainty, very slight indeed, but enough to affect, to some extent, the character of the appulse with *Jupiter*. In order to take account of this uncertainty, and to show at a glance our actual knowledge of the movements of this interesting body, I have solved his equations anew, and have expressed the elements in terms of an indeterminate quantity.

From the equations and quantities given in Dr. BAUSCHINGER's paper, we find at once:

$$
\begin{aligned}
\Delta\mu &= -\overset{''}{0}.4609 \quad +\overset{''}{0}.011399\,\Delta M°\\
\Delta\phi &= +64.227 \quad -1.396130\,\Delta M°\\
\Delta i &= -\ 2.079 \quad -0.113953\,\Delta M°\\
\Delta\Omega &= +11.870 \quad -0.017366\,\Delta M°\\
\Delta\omega &= -12.892 \quad -3.059290\,\Delta M°
\end{aligned}
$$

Now put

$$\Delta M° = -41''.53 \quad +1''.0\,r$$

where r is any number, positive or negative. When r is zero, this will reduce the value of $\Delta M°$ to that accepted by BAUSCHINGER as his definitive form. Applying these corrections, the definitive elements of the comet take the variable form:

1889 Sept. 30.5 Berlin Mean Time.

$$
\begin{aligned}
M° &= \overset{\circ}{0}\ \overset{\prime}{1}\ \overset{''}{5}.01 \quad +\overset{''}{1}.0\,r\\
\pi &= 1\ 34\ 54.99 \quad -3.0767\,r\\
\Omega &= 17\ 59\ \ 4.37 \quad -0.0174\,r\\
\omega &= 343\ 35\ 50.62 \quad -3.0593\,r\\
i &= 6\ \ 4\ \ 6.57 \quad -0.1140\,r
\end{aligned}
\left.\vphantom{\begin{aligned}\pi\\\Omega\\\omega\\i\end{aligned}}\right\}\ 1890.0
$$

$$
\begin{aligned}
\phi &= 28\ \ 5\ \ 5.75 \quad -1.3961\,r\\
\mu &= 501''.72306 \quad +0''.0114\,r
\end{aligned}
$$

In order to determine the limits within which r may vary, I had recourse to the equations of condition. I substituted in these the values of the corrections to the elements for different assumed values of r; the results of this substitution are shown in the following table, wherein the results for $r=0$ are taken direct from BAUSCHINGER's paper.

Normal Place		Weight		Residuals for Different Values of r									
		α	δ	$r=-40$		$r=-10$		$r=0$		$r=+10$		$r=+40$	
				$\Delta\alpha\cos\delta$	$\Delta\delta$	$\Delta\alpha\cos\delta$	$\Delta\delta$	$\Delta\alpha\cos\delta$	$\Delta\delta$	$\Delta\alpha\cos\delta$	$\Delta\delta$	$\Delta\alpha\cos\delta$	$\Delta\delta$
				s	″	s	″	s	″	s	″	s	″
1.	1889 July 28.5	23.6	20.6	+0.22	− 2.3	+0.17	− 0.9	+0.14	− 0.6	+0.12	−0.2	+0.06	+ 1.1
2.	Aug. 25.5	28.8	19 0	+ .15	− 0.1	+ .03	+ .2	− .01	+ .1	− .05	+ .3	− .17	+ 0.5
3.	Sept. 2.5	35.0	27.4	+ .04	− .1	− .04	+ .1	− .06	+ .1	− .09	+ .1	− .17	+ .2
4.	Sept. 18.5	25.4	19.5	− .09	+ .8	− .04	+ .6	− .02	+ .6	− .01	+ .6	+ .03	+ .4
5.	Sept. 30.5	24.3	15.8	− .20	+ 0.8	− .08	+ .5	− .04	+ .3	− .01	+ .2	+ .12	− .1
6.	Oct. 16.5	21.8	16.3	− .18	+ 1.2	− .03	+ .6	+ .02	+ .3	+ .07	+ .1	+ .20	− 0.6
7.	Oct. 24.5	16.3	9.5	− .05	+ 0.6	+ .06	− .2	+ .10	− .5	+ .21	− .8	+ .26	− 1.7
8.	Nov. 13.5	22.4	14.9	− .04	+ 1.2	− .02	+ 0.7	− .01	+ .3	− .01	+ .1	+ .01	− 0.9
9.	Nov. 21.5	20.7	18.8	− .05	+ 1.7	− .08	+ 1.2	− .09	+ .8	− .09	+ .5	− .12	− .5
10.	Dec. 19.5	19.3	19.4	+ .17	+ 0.1	+ .06	− 0.1	+ .02	− .4	− .01	− .6	− .12	− .9
11.	1890 Jan. 16.5	15.0	14.7	+ .20	− 1.4	+ .08	− .7	+ .05	− .5	+ .03	− .3	− .08	+ 0.3
12.	Feb. 13.5	17.0	14.6	− .01	− 1.6	− .03	− 0.3	− .04	+ 0.3	− .05	+0.9	− .08	+ 2.5
13.	Mar. 15.5	4.9	5.2	+ .23	− 5.3	+ .34	− 3.1	+ .33	− 1.7	+ 40	−1.0	+ .44	+ 1.8
14.	Nov. 22.5	2.0	2.0	+ .21	− 0.4	+ .28	+ 2.7	+ .20	+ 3.6	+ .32	+4.8	+ .38	+ 7.6
15.	Dec. 29.0	1.0	1.0	− .22	−14.3	− .14	−11.0	− .11	−10.2	− .08	−9.1	+ .01	− 7.8
16.	1891 Jan. 12.5	2.0	2.0	−0 38	+ 4.7	−0.17	+ 4.8	−0.09	+ 7.8	−0.02	+6.3	+0.19	+11.0
		[pvv]		1972″.6		767″.9		731″.5		844″.3		2038″.1	

From this table we see that for r equal to, or greater than, ±40, the residuals in both right-ascension and declination become larger than the accuracy of modern observations warrants, and further, that the signs of these residuals follow each other in a systematic way. Hence I conclude that the extreme possible limits of r are, as given, ±40. Again, the table shows that for small values of r the resulting residuals are nearly as satisfactory as those obtained with BAUSCHINGER's definitive elements; the signs appear to follow no regular law, and the residuals themselves are all within reasonable limits. Again, for values of r equal to ±10, the sum of the squares of the residuals is but very little in excess of that obtained with r equal to zero, being 731″.5 in this last case, and only 764″.9 for $r=-10$, and 844″.3 for $r=+10$. This investigation convinced me that the elements are still to be regarded as uncertain to a limited extent; that the true elements are most probably to be found by making r vary between the limits of ±15; that they are certainly included in those found by making r vary between the extreme limits of ±40.

Perturbations between 1889 *and* 1886. Previous experience had shown me that no conclusions can be drawn in regard to the comet's past history, unless these perturbations are most carefully computed. As already mentioned, I had once computed the perturbations due to *Jupiter* for this entire period, but with elements which differed slightly from those adopted in this present discussion. These perturbations of the elements had been computed with the usual regard to terms of the second and higher order. These old perturbations were now integrated for the date of each new computation, and the results applied to the above adopted elements; r being regarded as zero. With the elements thus derived for any given date the perturbations were again computed; and when the action of *Jupiter* became very large, these perturbations were integrated, applied, and the computations made anew. The final results were carefully tested by differencing, and by independent computations.

During this interval the actions of the following planets were considered: the *Earth*, *Mars*, *Jupiter*, and *Saturn*: the adopted mass of each being that given by OPPOLZER. The perturbations due to the *Earth*, and to *Mars*, were taken into account, from the epoch of osculation until October 1888; those due to *Saturn* until March 1887, from which time on *Jupiter* alone was considered. The intervals of computation were as follows: from September 1889 to 1887 March 25.5, twenty days; from March 1887 to 1886 December 25.5, ten days; and from December 1886 to 1886 October 26.5, four days.

The results thus obtained apply of course only to the mean values of the elements; that is, to that set of elements obtained by putting $r = 0$. For small values of r, the resulting perturbations during this interval do not differ appreciably from those found as above; but for values of r near the extreme limits, ±40, the differences begin to become noticeable, and to be rigorously accurate the perturbations should be recomputed for different values of r, at least for the interval between March 1887 and October 1886. This would detail considerable labor for the mere sake of a degree of accuracy of no practical value, for these extreme limits of r are retained merely to gauge the accuracy of our final conclusions. Hence I have applied the perturbations, found as above, directly to the adopted elements without regard to any changes that might be introduced by the different values that r may attain. The resulting elements are as follows:

1886 Oct. 26.5 Greenwich Mean Time.

$$
\begin{array}{rcll}
M^{\circ} & = & 213^{\circ}\ 15'\ 46''.82 & +1''.0\,r \\
\pi & = & 2\ \ 35\ \ 23.59 & -3.0767\,r \\
\Omega & = & 19\ \ \ 2\ \ 59.88 & -0.0174\,r \\
\omega & = & 343\ \ 32\ \ 23.71 & -3.0593\,r \\
i & = & 7\ \ 27\ \ \ 3.80 & -0.1140\,r \\
\phi & = & 31\ \ 48\ \ 33.33 & -1.3961\,r \\
\mu & = & 522''.09375 & +0.0114\,r \\
\log a & = & 0''.5548399 & -0.000\,006\,579\,r
\end{array}
\quad \left.\begin{array}{l} \pi \\ \Omega \\ \omega \\ i \end{array}\right\}\ 1886\ 0
$$

Hyperbolic Orbit about Jupiter. The general method followed, in making the transformation to *Jupiter* as the center of motion, was that given by LAPLACE in the *Mécanique Céleste*. In this computation there are but one or two points that need special mention. First, by means of differential formulas, derived from those given in WATSON, I formed general expressions in terms of the indeterminate, r, for the heliocentric rectangular coordinates of the comet, and for their derivatives with respect to the time. Again the position of *Jupiter* on the date of transformation, namely, 1886 October 26.5, was carefully taken from the *British Nautical Almanac*, the latitude and the longitude being reduced to the mean equinox of 1886.0. To find the derivatives of these quantities I took from the Almanac a series of complete positions of the planet, reducing each to the same mean equinox. The longitudes, for example, were tabulated, and the differences found to the fifth order, and from these differences, by means of the formulas for interpolation, I found the value that the first difference should have at the required date. Dividing this by four, the number of days' interval between the successive longitudes in the series, I found very accurately the rate of change of the longitude: and similar methods gave me the corresponding quantities for the latitude and the radius vector. The necessary data in respect to *Jupiter* are then as follows:

$$
\begin{array}{rcl}
\lambda & = & 197^{\circ}\ 38\ \ 31''.19 \\
\beta & = & +\ \ 1\ \ 17\ \ 46.32 \\
\log \rho & = & 0.736\,8529 \\
\Delta\lambda & = & +0^{\circ}\ 4'\ 31''.749 \\
\Delta\beta & = & -0''.88125 \\
\Delta \log \rho & = & -0.000\,002\,552\,5
\end{array}
$$

From these the rectangular coordinates and their derivatives were easily computed, and subtracting these results from the corresponding quantities for the comet, derived as above explained, we have for the relative coordinates of the comet, and for their derivatives:

$$
\begin{array}{rcll}
x & = & [8.569\,9931] & +[5.391\,2947]\,r \\
y & = & [9.439\,0153] & +[6.274\,5207]\,r \\
z & = & -[8.866\,2969] & +[5.346\,5331]\,r \\
dx & = & [6.438\,1305] & -[3.395\,9433]\,r \\
dy & = & [7.338\,6657] & -[3.205\,4896]\,r \\
dz & = & -[6.818\,0123] & -[1.964\,6821]\,r
\end{array}
$$

in which the logarithms of the actual numbers are given. The terms containing the second and higher powers of r are very small, and may be neglected entirely for all values of r between ±40, the extreme limits of possibility.

From these are derived the expressions for the three constants of areas, c, c', and c'', and for the major semi-axis of the comet's orbit about *Jupiter*, namely:

$$
\begin{array}{rcll}
c & = & +[4.753\,7030] & +[2.809\,6911]\,r \\
c' & = & -[4.631\,1140] & -[2.611\,8987]\,r \\
c'' & = & -[5.310\,0166] & -[3.270\,7178]\,r \\
a & = & -[8.932\,8649] & +[5.011\,7404]\,r
\end{array}
$$

and consequently for all admissible values of r the relative orbit was hyperbolic.

From the above quantities are readily derived the complete hyperbolic elements, which represent the variable orbit that the comet described about *Jupiter*, 1886 October 26.5. These elements in terms of the indeterminate, r, are as follows:

$$
\begin{array}{rcll}
\pi & = & 283^{\circ}\ 41'\ 55''.12 & +249''.59\,r \\
\Omega & = & 258\ \ 10\ \ 11.80 & -\ \ 14.21\,r \\
i & = & 74\ \ 52\ \ \ 8.00 & -120.66\,r \\
F & = & 76\ \ 34\ \ 22.82 & +\ \ 19.30\,r \\
a & = & -0.085\,6771 & +0.000\,010\,274\,r \\
e & = & 1.009\,7088 & +0.000\,179\,192\,r
\end{array}
$$

The time of peri-jovian passage is found, neglecting the effect of the solar perturbations, to be

$$1886 \text{ July } 19.870\,000 \quad +0.081\,353\,r$$

And using the elements for July 20, I find for the perijovian distance of the comet the following, in which the semi-diameter of *Jupiter* is taken as the unit:

$$q = 2.31 \quad + 0.033\,r$$

That is, the comet not only passed through the system of *Jupiter's* satellites, but it actually passed within the orbit of the first satellite, whose mean distance is 5.93 radii of the planet. Taking the extreme limits of r we are safe in saying that the comet passed the center of *Jupiter* at a distance not greater than 3.63, and not less than 1.00 radii of the planet. In other words, the center of the comet may have touched the surface of *Jupiter*, and it certainly approached that surface to within a distance of 2.63 radii of the planet, or only 112 300 miles. Even this latter is a very small quantity.

For the most probable hypothesis, that of $r = 0$, the comet was 2.65 days within the system of *Jupiter's* satellites, and during this time it made nearly a complete circuit about the planet, passing over an arc of 313° of longitude. The comet entered the Jovian system in longitude 118° on July 18.77, passed the planet July 20.10 at a distance of only 2.28 radii, and July 21.43 left the system in longitude 71°. During this time it must have collided with one or more of the satellites.

(*To be continued.*)

OBSERVATIONS OF COMETS,

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

1893 Cincinnati M.T.		*	No. Comp.	☄ — *		☄'s apparent		log pΔ	
				Δα	Δδ	α	δ	for α	for δ
				COMET *b* 1893.					
	h m s			m s	′ ″	h m s	° ′ ″		
Aug. 1	8 14 18	1	4 , 4	+1 16.62	+10 14.7	12 1 3.04	+15 37 0.1	9.661	0.686
	8 14 18	2	8 , 8	−0 42.04	− 4 48.8	12 1 3.04	+15 36 56.6	9.661	0.686
3	8 22 2	3	8 , 8	−2 32.27	− 2 41.7	12 3 57.75	+14 34 5.2	9.664	0.699
5	8 16 50	4	6 , 6	−0 5.40	+ 3 5.7	12 6 25.62	+13 38 46.1	9.663	0.703
	8 16 50	5	6 , 6	−1 14.29	− 0 43.6	12 6 25.45	+13 38 37.6	9.663	0.703
7	8 25 0	6	4 , 4	+2 52.70	−14 59.5	12 8 34.06	+12 48 59.7	9.667	0.714
	8 25 0	7	6 , 6	−0 3.91	+ 4 33.3	12 8 33.77	+12 49 5.1	9.667	0.714
8	8 13 47	8	8 , 8	+0 37.12	+ 1 22.7	12 9 30.81	+12 26 29.1	9.663	0.711
12	8 10 13	9	8 , 8	−1 36.32	+ 0 27.5	12 12 52.16	+11 5 13.4	9.664	0.720
14	8 10 38	10	12 , 12	−0 24.02	+ 0 39.0	12 14 18.62	+10 29 47.8	9.665	0.725
				COMET *a* 1893 (FINLAY).					
Aug. 12	15 6 23	11	8 . 8	+0 54.62	− 1 18.3	6 6 21.69	+23 12 36.7	*n*9.694	0.679

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	11 59 45.64	+0.78	+15 26 45.7	−0.5	Weisse-Bessel 2, XI, 1144
2	12 1 44.29	+0.79	+15 41 45.7	−0.3	Weisse-Bessel 2, XI, 1185
3	12 6 29.24	+0.78	+14 36 47.5	−0.6	Weisse-Bessel 2, XII, 92
4	12 6 30.26	+0.76	+13 35 41.3	−0.9	Weisse-Bessel 1, XII, 54 ; Schjellerup 4403
5	12 7 38.97	+0.77	+13 39 22.2	−1.0	Weisse-Bessel 1, XII, 76 ; B.B. VI, 13°2507
6	12 5 40.61	+0.75	+13 4 0.4	−1.2	Gött. 2, 3101 ; Schjellerup 4395
7	12 8 36.92	+0.76	+12 44 33.1	−1.3	Schjellerup 4415
8	12 8 52.93	+0.76	+12 25 7.8	−1.4	Weisse-Bessel 1, XII, 95
9	12 14 27.72	+0.76	+11 4 47.9	−2.0	Weisse-Bessel 1, XII, 192 ; Münich 1, 7919
10	12 14 41.91	+0.73	+10 29 10.9	−2.1	Glas. 1, 3149 ; Gött. 2, 3149 ; Münich 1, 7925
11	6 5 26.16	+0.91	+23 13 46.4	+8.6	Paris 7365 ; Berlin A.G.Z.

NOTE. — Comet of FINLAY on August 12 was exceedingly faint. Observation difficult.

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RESEARCHES UPON COMET 1889 V,

BY CHARLES LANE POOR

(Continued from No. 302.)

In *Astronomical Journal*, no. 302, I gave the definitive elements, which represent the osculating hyperbola that the comet was describing about *Jupiter* on 1886 October 26.5. It is very desirable to have a check upon the accuracy with which the transformation to the relative orbit was made. A simple, but complete, control upon methods and computations is secured as follows.

The general method used, which was first proposed by D'ALEMBERT, consists in supposing the planet to have a "sphere of activity," within which the relative motion of the comet is affected only by the planet's attraction and beyond which the absolute motion of the comet about the sun is performed as if the sun alone acted upon it. The radius of this sphere depends upon the mass of the planet and its distance from the sun. This was the simple method afterwards used by LAPLACE and again by LEVERRIER. But, while beautiful and simple, it neglects entirely the effect of the sun as disturbing body whilst the comet is traversing its relative orbit about the planet. It will become more effective, if we merely use the idea of the "sphere" as defining approximately the point, at which we may conveniently transpose the sun and the planet, as disturbing and central forces; and after the transformation has been made, we may treat the sun and the comet as bodies revolving about the planet as central body; the sun acting as a disturbing body upon the comet. The perturbations of the comet by the sun may be computed in a manner entirely similar to the usual methods. The exact point in the comet's orbit, at which the transformation is made, is of no great importance, provided that the perturbations be carefully computed both before and after; and this fact furnishes us with the desired, and an absolute, control.

As the comet approaches *Jupiter* in its orbit about the sun, compute carefully the planetary perturbations, thus deriving the osculating elliptic elements of the comet for two dates, t and t', one of which, t, is that upon which the comet enters the so called "sphere," the other, t', being ten days or two weeks later, or after the comet is well within the sphere. From the osculating elements of date t compute the heliocentric coordinates and their derivatives for that date, thence find the coordinates and velocities relative to *Jupiter*, and thence by the transformation-formulas the osculating hyperbola about *Jupiter*; with these hyperbolic elements compute the solar perturbations for the interval $t' - t$, apply them and thus derive the osculating hyperbola for the date, t'. With these elements we may readily compute the coordinates, x', y', z', of the comet referred to *Jupiter* for the date t'.

Then with the osculating elliptic elements of the comet about the sun, as already derived for the date, t', we compute first the heliocentric coordinates of the comet and thence derive the coordinates, x'', y'', z'', of the comet referred to *Jupiter* for the date t'. If all formulas and computations are correct, we shall have absolutely,

$$x' = x'' \qquad y' = y'' \qquad z' = z''$$

and a perfect control is secured.

In my work, the date chosen to make the transformation to *Jupiter* as the center of motion was, as has already been given, 1886 Oct. 26.5; the interval, $t' - t$, was taken as sixteen days, thus making the check-date October 10.5. A longer check-interval cannot well be used, for the perturbations of the elliptic elements become more and more difficult of computation as we advance nearer and nearer to *Jupiter*. I first applied to the hyperbolic elements for October 26.5, that correspond to r equal to 0, the solar perturbations for sixteen days; thus deriving the osculating hyperbolic elements for October 10.5. From these I then found the rectangular coordinates, x', y', z', of the comet referred to *Jupiter*. Then to the elliptic elements of October 26.5 I applied the pertubations due to *Jupiter* for the same interval, and thus found the osculating elliptic elements of the comet about the sun for October 10.5. From these I then computed the heliocentric coordinates of the comet and thence the rectangular coordinates, x'', y'', z'', of the comet referred to *Jupiter*. Comparing the two sets of results thus found, I have as follows:

$$x'' - x' = -0.000006$$
$$y'' - y' = +0.000052$$
$$z'' - z' = +0.000049$$

These differences are all considerably less than a tenth of one per cent of the corresponding quantities, that in z being relatively by far the largest. Such errors may well arise from the unavoidable use of mathematical tables, and are small enough to establish the substantial accuracy of both methods and computations.

In order to secure a control on the values of the coefficients of r in the hyperbola about *Jupiter* I made an independent computation of the elements for $r = +20$. That is, in the given elliptic elements for October 26.5 I gave r the above value, and from the resulting elements derived the corresponding relative hyperbolic elements, and compared the results with those obtained directly from the definitive hyperbolic elements by substituting for r, $+20$. Although the check-computation was made with five-place tables the results of this comparison were satisfactory, as will be seen from the following, where the residuals are taken in the sense, check—computation:

$$\Delta F = +0'.32$$
$$\Delta i = -0'.50$$
$$\Delta a = -0.000\,012$$

Solar Perturbations, October to March 1886. During the time that the comet was traversing the relative orbit about *Jupiter*, the sun acted as a disturbing body and this action had to be taken account of. In order to do this I computed the solar perturbations for the entire interval between October and March, using an eight-day period. The method used in this work was that of the variation of constants, the necessary formulas being specially derived from the equations of hyperbolic motion as given by WATSON. The quantities of which the perturbations were found are as follows: the four elements, π, Ω, i, and e and the two auxiliaries, r and N, (WATSON's notation.) In this form I found the perturbations very easy of computation, and the method, on the whole, decidedly preferable to that of the "variation of coordinates," which I had used in a former discussion of this same problem. The great trouble with this latter method is the indirect terms of the differential coefficients, which, owing to the very small value of r, become large and difficult to approximate to. This necessitates the integration of the perturbations, their application, and the derivation of new osculating elements at several epochs during the interval under discussion.

In computing these perturbations, the elements corresponding to the mean value of r were used, and rigorously, therefore, the results apply only to the mean hyperbola. All precautions were taken for allowing for the terms of the second and higher orders; the variable elements for the date being used for each computation, and the results tested by differencing and by independent computations. A very fair check on these perturbations was furnished by my previous investigation of this same problem, in which the method of variation of coordinates was used. In that work, however, a slightly different hyperbola was used; and the results of the two methods cannot therefore be directly compared, but, making allowance for this fact, the results are in substantial agreement, thus showing that the entire computation of these perturbations is in the main correct.

For the date chosen to transfer the center of motion back to the sun, namely 1886 March 24.5, the integrated values of these solar perturbations are as follows, the osculating hyperbola being that of October 26.5:

$$\begin{aligned} \Delta\pi &= +\ \ 0^\circ\ 31'\ 44''.0 \\ \Delta\Omega &= -\ \ 2\ \ \ 1\ 14.6 \\ \Delta i &= -\ 11\ \ \ 9\ 53.2 \\ \Delta e &= +\ 0.001\,68500 \\ \Delta r &= -\ 0.000\,42543 \\ \Delta N &= +\ 0.040\,11960 \end{aligned}$$

For those hyperbolas that correspond to large positive or negative values of the indeterminate r, the perturbations would differ considerably from those above given, but on account of the great labor involved in making separate determinations for various values of r, I have used the above mean values and have applied them directly to the various hyperbolas.

The results of this application of the solar perturbations are shown in the following table, wherein are to be found various sets of hyperbolic elements corresponding to different values of r between the extreme limits of ±40. These elements all are osculating for March 24.5 and with the exception of the mean set, they are all given in decimals of a minute of arc and in logarithms of but five places. This table shows at a glance the various possible paths that the comet may have described about *Jupiter*, the most noticeable fact being the great variation of the eccentricity; this element changing from 1.0042, for $r = -40$, to 1.0186, for $r = +40$.

HYPERBOLIC ELEMENTS FOR DIFFERENT VALUES OF r.
Epoch, 1886 March 24.5.

	$r = -40$	$r = -20$	$r = -10$	$r = 0$	$r = +10$	$r = +20$	$r = +40$
π	281° 27'.25	282° 50'.55	283° 32'.10	284° 13' 39"	284° 55'.21	285° 36'.75	287° 0'.05
Ω	256 18 .39	256 13 .69	256 11 .32	256 8 56	256 6. 58	256 4 .21	255 59.50
i	65 2 .69	64 22 .47	64 2 .36	63 42 15	63 22. 14	63 2 .03	62 21.80
F	—77 55 .10	—77 47 .00	—77 43 .00	—77 38 50	—77 34. 70	—77 30 .50	—77 22.06
log a	8.94 876	8.94 766	8.94 712	8.946 5697	8.94 602	8.94 548	8.94 440
log e	0.00 183	0.00 338	0.00 415	0.004 9202	0.00 569	0.00 646	0.00 798
log v	7.94 007	7.94 172	7.94 254	7.943 3570	7.94 418	7.94 499	7.94 662

Transformation to the Sun. It was impossible to find the orbit about the sun directly in terms of the indeterminate, r; for the coefficients of this quantity in the hyperbola about *Jupiter* were so large that, in the differential formulas of the transformation, it would have been necessary to use the terms of the second and even of higher orders. This would have made the formulas too complicated for practical application. The method used, therefore, to determine the various paths about the sun, was to take the hyperbolas, given in the above table and which correspond to seven different values of r, and to effect the transformation with each one of these separately, and to form a table of the results from which the orbit corresponding to any value of r, may be found by simple interpolation.

The coordinates and velocities of *Jupiter* on the date of transformation, March 24.5, were found in the manner already explained and are as follows:

$$\lambda = 181^\circ\ 20'\ 4''.82$$

$$\beta = +1\ \ 17\ \ 50\ .70$$

$$\log \rho = 0.736\,4961$$

$$\Delta\lambda = +0^\circ\ 4'\ 32''.206$$

$$\Delta\beta = +0\ \ 0\ \ 0\ .868$$

$$\Delta \log \rho = +0.000\,00581$$

From these the rectangular coordinates and velocities, the ecliptic being taken as the fundamental plane, are at once derived. Then from the various hyperbolas in the above table are computed the corresponding quantities for the comet in reference to *Jupiter* as center and by combining the results, thus obtained, with those found for *Jupiter*, we derive the heliocentric coordinates and velocities of the comet. These latter quantities are exhibited in the following table; in which the logarithms of the actual numbers are given.

HELIOCENTRIC COORDINATES AND VELOCITIES OF THE COMET.

1886 March 24.5.

r	x	y	z	dx	dy	dz
—40	n0.766 63	9.230 27	n8.569 22	6.007 67	n7.961 28	7.016 43
—20	n0.737 59	9.195 49	n8.707 98	6.246 90	n7.958 99	7.055 35
—10	n0.738 02	9.178 00	n8.753 12	6.322 45	n7.957 89	7.071 03
0	n0.738 4330	9.159 8339	n8.789 5649	6.385 4750	n7.956 7976	7.085 1617
+10	n0.738 83	9.141 17	n8.819 95	6.439 62	n7.955 69	7.098 02
+20	n0.739 22	9.121 89	n8.845 59	6.487 15	n7.954 59	7.109 80
+40	n0.739 95	9.081 11	n8.886 32	6.567 86	n7.952 36	7.130 73

From these are derived the expressions for the three constants of areas, c, c' and c'', and that for the semi-axis major of the comet's orbit about the sun. The values of these quantities for the definitive orbit, or for r equal to zero, are as follows:

$$\log c = 8.694\,9230$$

$$\log c' = n7.822\,6181$$

$$\log c'' = n6.581\,9047$$

$$\log a = 1.081\,2668$$

and consequently the resulting orbit is an ellipse of 41.87 years' period.

From these and from the similar quantities, derived for the different values of r, are readily found the complete elliptic elements which represent the various possible orbits of the comet about the sun on 1886 March 24.5. All the final results are collected and exhibited in the following table, in which the given elements are osculating for the date of transformation and are referred to the mean equator and equinox of 1886.0. The dates of the perihelion passage, as there given, are all in the year 1886.

ELLIPTIC ELEMENTS OF THE COMET FOR DIFFERENT VALUES OF r.

Epoch, 1886 March 24.5.

	$r = -40$	$r = -20$	$r = -10$	$r = 0$	$r = +10$	$r = +20$	$r = +40$
π	184° 59′.7	186° 10′.1	186° 42′.2	187° 14′ 0.″7	187° 45′.8	188° 17′.5	189° 23′.6
☊	181 38 .8	182 38 .7	182 59 .8	183 17 16. 8	183 32 .1	183 44 .6	184 4 .5
i	6 28 .7	7 7 .0	7 23 .7	7 39 17. 6	7 54 .1	8 8 .1	8 34 .3
ω	3 20 .9	3 31 .4	3 42 .4	3 56 43. 9	4 13 .7	4 32 .9	5 17 .1
$\log a$	1.096 05	1.088 59	1.084 92	1.081 2668	1.077 51	1.073 82	1.066 24
$\log e$	9.751 04	9.744 78	9.741 61	9.738 4516	9.735 15	9.731 87	9.725 03
$\log \mu$	1.905 94	1.917 12	1.922 63	1.928 1064	1.933 74	1.939 28	1.950 65
T	30.0820 May	13.6350 June	19.3820 June	24.0752 June	29.0700 June	4.2750 July	14.6600 July

In making the transformation from the hyperbola to the ellipse, the check already described was again successfully applied, although the agreements were not quite as close as in the former work. The seven independent computations made with the different values of r also formed a partial check on the whole work.

The results embodied in the above table are in substantial agreement with those obtained in my former discussion of the problem, the chief difference being in the period, which is now found to be slightly smaller than the old work indicated. As these two investigations were utterly independent, different formulas and different methods being used in many parts of the work, the agreement of the results establishes, I think, the general correctness of the work.

So far, however, we have merely determined the orbit that the comet was describing at the moment when it entered the so-called "sphere of activity" of the planet. For some months before this time, the planet and comet were so close together that the orbit of the latter was continually subject to change and it is, therefore, necessary to compute the perturbations for this interval. For this purpose the ordinary method of the variation of constants was used, and, in order to take account of terms of the second and higher orders, the variable elements for the date were used for each computation. The intervals of computation were as follows: from 1886 March 24.5 to January 3.5, four days; from January 1886 to July 7.5, 1885, ten days; and from July 1885, to 1884 March 14.5, forty days. During this entire time *Jupiter* alone was considered, and all the computations were made with those elements which correspond to r equal to zero. Of course the perturbations thus obtained apply only to the mean set of elements as given in the above table, and, while those that might be derived from any of the other sets of elements would differ appreciably from those as above computed, yet on the whole the final results would not be greatly affected by these differences. Hence I have applied the perturbations, found as above, directly to the various sets of elements without regard to any changes that might be introduced by separate computations. The resulting definitive elements of the comet, those corresponding to r equal to zero, are then as follows:

1884 March 14.5. Greenwich Mean Time.

$$\begin{array}{rcl} L &=& 161^{\circ}\ 49'\ 54'' \end{array}$$
$$\left.\begin{array}{rcr} \pi &=& 188\ 46\ 12 \\ \Omega &=& 186\ 19\ 14 \\ \omega &=& 2\ 26\ 58 \\ i &=& 6\ 45\ 44 \end{array}\right\}\ 1886.0$$
$$\begin{array}{rcl} \phi &=& 26\ 47\ 33 \\ \mu &=& 113''.0620 \\ \log a &=& 0.9977932 \end{array}$$

From these results the time of perihelion passage is found to be

1886 July 20.2416

and the period of the comet appears as

31.38 Julian years.

The elements corresponding to any other value of r can be derived directly from the table by applying the differences between the above set and the tabular set of $r = 0$. It is only necessary to note here that the final period of the comet may vary between the extreme limits of 32.60, and 30.17 years, which limits are attained for r equal to -40 and $+40$, respectively.

Comparing the above results for different values of r with those obtained by former investigations, by both Dr. CHANDLER and myself, one or two facts stand out pretty clearly. First, the angular elements of the orbit are known with a reasonable degree of accuracy; the inclination and the line of nodes appearing as practically the same in all the discussions, while the longitude of the perihelion varies but a few degrees from the value assigned in Dr. CHANDLER's original paper. Second, the size of the orbit is by no means so well determined; it varies, in the different investigations, from 26.5 years in Dr. CHANDLER's to 32.6 in the present paper. The mean result of the present investigation, however, is, I think, very near the truth. But, however accurately the various transformations may be made, exercise what care we will in the investigation, there is still bound to be at present an uncertainty of fully two years in this most critical element; and this uncertainty is due, not to any incompleteness of method or formulas, but to the original observations themselves.

As to Identity with Comet of Lexell 1770. LEXELL's comet underwent its notable disturbance in the year 1779, and, moreover, this disturbance took place in that part of *Jupiter's* orbit in which Comet 1889 V suffered its great change of elements, as above discussed, in the year 1886. Between these two appulses there intervened a period of 107 years, which period must be accurately accounted for in order to establish the identity of these two remarkable bodies. But, assuming the substantial correctness of the present investigation, we cannot directly account for these necessary years. For the period of Comet V in 1884, or previous to its disturbance, has been shown to be 31.86 ±1.50 years, which is not an aliquot part of 107. Hence, unless in the intervening years the comet suffered other and marked disturbances in its orbit, the entire question as to identity between the two bodies falls at once, and further investigation of the subject is useless.

An investigation shows us that such disturbances did take place during this interval, but leaves us utterly in the dark as to the resulting changes in the orbit. In this regard we note, first, that there could be no possible approach to *Saturn*, close enough to cause any marked changes. For the orbits of these two bodies, *Saturn* and the comet, intersect in longitudes 80° and 300° approximately, varying a few degrees either way from these figures according to the value we assign to the indeterminate. r. The comet was in these longitudes at the following times, respectively: 1881.4, 1850.0, 1818.6, 1787.3 and 1860.4, 1829.0, 1797.6; while *Saturn* passed the corresponding points in its orbit at the following times: 1884.5, 1855.1 1825.6, 1796.4 and 1873.0, 1843.5, 1814.0, 1784.6; thus the closest approach took place in the years 1881 to 1884, but even at this time the two bodies did not come within five astronomical units of each other and the resulting perturbations were inappreciable. This fact, that there could have been no large disturbance by *Saturn*, is of special importance, as we shall see hereafter.

Second, in regard to possible disturbances by *Jupiter*, we note that such did take place, the facts being best shown by the following small table, which gives, for the extreme and the mean values of r, the times at which the comet passed perihelion and the corresponding times at which *Jupiter* was in the same longitude.

APPROACHES TO *Jupiter*.

Comet in longitude 188°			*Jupiter*	Character of Approach		
$r = -40$	$r = 0$	$r = +40$		$r = -40$	$r = 0$	$r = +40$
1886.55	1886.55	1886.55	1886.50	+0.05	+0.05	+0.05
1853.95	1855.17	1856.38	1850.92	+3.03	+4.23	+5.46
1821.35	1823.79	1826.21	1827.20	−5.85	−3.41	−1.01
1788.75	1792.41	1796.04	1791.62	−2.87	+0.79	+4.42

From this we see that close approaches may have occurred in the years 1827 or 1791, depending upon the value taken by the indeterminate r. Each of these possible appulses needs a few words; and first in regard to that of 1827. This only begins to merit the title of an approach for the extreme positive value of r, and even then is hardly close enough to greatly alter the comet's orbit. But for values of r slightly in excess of this limit the disturbance at this time becomes more marked and of such a character as to considerably reduce the comet's periodic time; that is, before this disturbance the period would have been some years longer than it was between this time and 1886. In fact, by assigning r a value somewhere between +50 and +60 we could give to this approach a character such that the previous period of the comet must have been about 48 years and this would bring the comet around in 1774 to the position occupied by LEXELL's comet in that year. In other words, there is a possibility that for a large positive value of r the identity of the two comets might be established, but in my former paper I showed that such a value of r is extremely improbable, if not impossible,—the extreme limits of variation there assigned being ±40.

On the other hand the appulse in 1791 is indicated by the mean set of elements and becomes extremely close for small negative values of r. By causing r to vary between the limits of ±20, we can give to this approach almost any desired character and so obtain a great variety of possible elements for the comet before this time. Such a variation of r is well within the bounds of possibility and of probability also. In fact, while the data, at present available, point conclusively to an approach to *Jupiter* in 1791 and to consequent large changes in the orbit of the comet at that time, yet they are not sufficient to enable us even roughly to approximate to the character of those changes. One point is, however, I think, reasonably clear and that is, granted such an appulse took place, the present comet cannot possibly be the same as Lexell's. For, in this case, the supposition of identity would require the comet to have between 1779 and 1791 a period identical with that of *Jupiter*, one might almost say, an orbit identical with that of *Jupiter*.

There is another method by which the question of identity may be investigated, and that is, by means of the criterion formulated by M. TISSERAND. By an investigation of the path of a comet through the planet's "sphere of activity," he derives a function, n, of the comet's elements, which remains practically unaltered, however great the change in the separate elements. This function is given by the formula

$$n = \frac{1}{a} + \frac{2\sqrt{A}}{R^2}\sqrt{p}\cos i$$

where a, p and i are respectively the semi-axis major, the parameter and the inclination of the comet's orbit, and A and R, the semi-axis major and the radius vector of the disturbing planet at the point of closest approach. Now the action of *Jupiter*, even repeated at several very close appulses, can cause but a very slight variation in the value of this function, when taken in respect to that planet; but, on the other hand, the action of another planet, *Saturn* for example, may at one approach change considerably the value of this quantity, taken with respect to *Jupiter*, although it must leave unchanged the value of the function, taken with respect to *Saturn* itself. Hence, in order to establish the identity of Comet V with that of Lexell, both of which were disturbed by *Jupiter*, we must either show that the ns for the two bodies are practically the same, or that there was an intermediate disturbance by another planet.

The values of this function for the two comets under discussion, and taken with respect to *Jupiter*, are exhibited below. In order to show the possible variations in n, due to one approach, I computed its value with those elements of Comet V, that correspond to the following four points of its path: 1st, March 1884, the action of *Jupiter* insensible; 2d, March 24.5, 1886, entrance to the sphere of activity; 3d, October 26.5, 1886, exit from the sphere; 4th, September 30, 1889, the action of *Jupiter* again inappreciable. For Lexell's comet I used the elements given by LeVerrier.

Comet 1889 V, 1st, $n = 0.5289$
" 2d, $n = 0.5242$
" 3d, $n = 0.5233$
" 4th, $n = 0.5294$
Lexell's Comet $n = 0.4852$

Comparing the values derived for Comet V, in pairs, according to the distance of the comet from *Jupiter*, the agreement of results is striking. We thus see that even this remarkably close approach produced only a total change of 0.0005 in the value of this function and, as the change necessary to bring it into agreement with that for Lexell's Comet is 0.0442, we at once conclude that no intermediate approach, or series of approaches, to *Jupiter* can satisfy the requirements of this criterion. This tends to prove, as was long ago pointed out by M. Schulhof, (*Bulletin Astronomique*, December 1889) that the two comets, Lexell and 1889 V, are not identical, unless it can be shown that there was a strong intermediate disturbance by *Saturn*.

The numerical results obtained in the present discussion show that there could have been no such approach to *Saturn* between the years 1779 and 1886 and this fact, considered in the light of Tisserand's criterion, goes very far towards disproving the hitherto supposed identity of these two noteworthy comets.

This entire question may be briefly summed up as follows: on the one hand, we have a few striking coincidences, all pointing towards identity, on the other hand stand Tisserand's unsatisfied criterion and the numerical results of a long and careful investigation. For my own part, however, I do not think that we can arrive at any definite conclusion at present; we must await the reappearance of the comet in 1896. The first few observations in that year will furnish a very fair approximation to the value of r, from which, by the aid of the tables above given, we can derive the elements of the orbit that the comet was describing in 1884, previous to the disturbance. The elements thus derived should be very close to the true ones, and should furnish a definite solution to the vexed question of identity. When the definitive elements of the two appearances are deduced, then the entire subject should be most carefully re-investigated.

In another paper of the present series I hope to give the results of an investigation upon the path of the comet, while in the immediate vicinity of *Jupiter*. The disruption of the comet and the possibility that a portion of it was permanently drawn into the Jovian system, thus forming a new satellite, will be among the questions therein discussed.

PHOTOGRAPHY OF METEORS,

By W. L. ELKIN.

An attempt has been made at this Observatory to ascertain the feasibility of determining the paths of meteors, and the radiant areas of a shower by photography. On the nights of August 9 and 10 last a camera, mounted on our 8-inch equatorial, was kept directed during 4 hours to points near the radiant of the Perseids. The lens was a Voigtländer portrait combination of 6 inches aperture, and 32 inches equivalent focal length, and the part of the plate exposed measured 7½ by 8½ inches, thus covering a field of about 200 square degrees. A visual watch was kept on the region under exposure by Mr. Brown, Dr. Chase and myself, and of the ten meteors thus noted on August 9, *three* were found on the plates when developed, one of which, however, was not a Perseid. On August 10 only three or four meteors were seen which should have fallen on the plates, none of them so bright as a second magnitude star, and no trails show on the photographs. On this night the shower was very slight. It seems therefore safe to conclude that with a battery of even only six or seven such cameras a sufficient number of meteors would be secured on an average display of the Perseids to locate the radiation, and define its character with certainty.

Mr. John E. Lewis, of Ansonia, some ten miles from New Haven, working in collaboration with us, and using a lens of about 4 inches aperture, and 15 inches focus, secured the trail of the brightest meteor on our plates of August 9. The displacement of the track amounts to about six degrees, and when the plates have been measured the path of this meteor will be determined with an accuracy hitherto unknown, so far as I am aware.

Yale University Observatory, New Haven, Conn., 1893 *Aug.* 31.

THE AUGUST PERSEIDS, 1893,

By EDWIN F. SAWYER.

The earth appears to have encountered a very attenuated portion of the meteor stream this year; observations at Brighton, Mass., and Wolfeboro, N. H., on the evenings of August 8, 9 and 10, furnishing very meagre results. In the absence of the writer from Brighton, for a much needed rest, Mr. Elmer E. Monroe, who had been previously instructed as to the method of recording the intensity of the shower, and who had kindly volunteered to make the necessary observations, reported in reference to the display as follows:

Began observations at 9 hours on the evening of Aug. 8, and continued the same on the two following evenings; the conditions for observing being very favorable, there being no moonlight, and clear weather prevailing. The observations were prolonged until 11 hours on each evening. Meteors were found to be notably scarce on all of the evenings, the Perseids, however, prevailing on Aug. 9 and 10, while very scarce on Aug. 8. The number recorded each evening, and their magnitudes, were as follows:

Aug	Duration of Watch	Length of Watch	Magnitudes					Total	Perseids
			$>1^M$	$=1^M$	$=2^M$	$=3^M$	$=4^M<$		
	h m h m	h m							
8	9 0 to 11 0	2 0	0	4	10	7	2	23	6
9	8 35 to 11 0	2 25	1	7	9	2	2	21	15
10	8 40 to 11 0	2 20	2	14	13	9	7	45	35
		6 45	3	25	32	18	11	89	56

The hourly rate for the Perseids increased from only 3 on the 8th, to 6 on the 9th, and 15 on the 10th, showing a decided, although feeble maximum on the latter date. Of all the meteors recorded 63 per cent. were Perseids.

At Wolfeboro, the writer observed on the evenings of Aug. 9 and 10, but found the shower so feeble that the watch was not prolonged. On Aug. 9, from 10^h to 11^h, only 8 meteors were seen, 7 being Perseids; and on Aug. 10 from 10^h to $10^h 30^m$, and again from 11^h to $11^h 30^m$, 28 were noted, 23 being Perseids.

My star-charts not being at hand, the time was occupied in noting the number falling, their magnitudes, and whether from the Perseid radiant or not. A few well observed tracks of bright meteors near the radiant and well known stars were, however, located on a hastily constructed map, and are given below. A few tracks quite well observed by Mr. Monroe, are also included.

Meteor Tracks Mapped.

No.	Date 1893	Boston M.T.	Mag.	Observed Path				Length of Path	Wt.	Remarks
				From		To				
				R.A.	Decl.	R.A.	Decl.			
		h m		°	°	°	°	°		
1	Aug. 9	9 20	1	18	+59	356	+59	12	2	From near δ *Cassiopeae*
2	9	9 40	2	176	+65	170	+50	15	2	Not a Perseid
3	10	10 15	4	8	+52	352	+43	15	4	Streak 2 seconds; Perseid
4	10	10 47	4	26	+64	16	+66	5	2	Short; Perseid
5	10	11 10	>1	20	+54	11	+52	5	3	Short; Perseid; streak 2 seconds
6	10	11 21	1	21	+54	16	+52½	4	3	Short and rapid: Perseid
7	10	11 30	2	50	+60	52½	+60½	1	3	Very short; Perseid

Nos. 1, 2 and 4 were recorded by Mr. Monroe. From the paths mapped on the 10th, the radiant point was fairly well determined as at R.A. 44°, Decl. +57°. Center of observation, *Perseus*.

Brighton, 1893 *Sept*. 2.

FILAR-MICROMETER OBSERVATIONS OF COMET 1892 VI,

MADE WITH THE 26 INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA,

BY EDGAR ODELL LOVETT.

[Communicated by Prof. Ormond Stone, Director.]

1893 L. McC. M.T.		*	No. Comp.	☄ — *		☄'s apparent		$\log p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
June 7	12 36 37	1	8	. . .	−5 53.1	. . . .	−24 58 16.0	. .	0.895
	12 43 48	1	32	−0 54.31	. . .	17 39 33.13	. . . .	7.995	. .
9	12 6 57	2	32	−1 33.54	. . .	17 36 48.84	. . . .	8.516	0.894
	12 7 58	2	8	. . .	−2 26.9	. . . .	−24 40 50.5	. .	. .
July 3	11 29 37	3	14	+4 19.53	. . .	17 10 37.34	. . .	9.169	. .
	11 31 1	3	4	. . .	−4 24.3	. . . .	−21 33 25.0	. .	0.874
5	10 42 5	4	40	+0 25.23	. . .	17 9 10.76	. . . .	8.818	. .
	10 47 34	4	15	. . .	−5 38.7	. . . .	−21 20 33.5	. .	0.878
6	11 26 31	4	20	−0 18.04	. . .	17 8 27.48	. . . .	9.209	. .
	11 56 31	4	6	. . .	+0 46.3	. . . .	−21 14 8.5	. .	0.864
7	11 20 4	4	52, 17	−0 58.08	+6 3.6	17 7 47.44	−21 8 51.1	9.228	0.871
8	11 38 6	5	56, 10	+0 3.85	+0 23.0	17 7 8.0	−21 2 6.3	9.325	0.865
9	11 33 6	5	8	. . .	+6 7.6	. . . .	−20 56 21.6	. .	0.862
	11 43 22	5	32	−0 33.67	. . .	17 6 30.4	. . . .	9.323	. .
10	9 13 43	6	44	−2 33.71	. . .	17 5 59.92	. . . .	n8.884	. .
	10 8 51	6	6	. . .	−0 8.9	. . . .	−20 50 55.9	. .	0.877
	11 9 17	6	46	−2 36.51	. . .	17 5 57.12	. . . .	9.237	. .
	11 12 33	6	15	. . .	−0 1.2	. . . .	−20 50 48.2	. .	0.868
12	11 35 25	7	56	. . .	+1 37.7	. . . .	−20 39 42.4	. .	0.868
	11 37 46	7	7	+0 3.03	. . .	17 4 49.64	. . . .	9.221	. .

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	17 40 24.96	+2.48	—24 52 14.0	— 8.9	Argelander 17192
2	17 38 19.88	+2.50	—24 38 14.6	— 9.0	Argelander 17151
3	17 6 15.18	+2.63	—21 28 49.8	—10.9	Argelander 16458
4	17 8 42.90	+2.63 +2.62	—21 14 44.0	—10.8 —10.7	Argelander 16518, 19, 20
5	17 7 1.5	+2.62 +2.63	—21 2 18.5	—10.8 —10.7	Washington Zones 264, 11
6	17 8 31.00	+2.63	—20 50 36.4	—10.6	Argelander 16509, 11
7	17 4 43.99	+2.62	—20 41 9.1	—11.0	Bonn Zones 20° No. 7

NOTES.

June 7. Seeing good. Comet condensed and nucleus well defined. No tail. Round, and about 3′.5 in diameter.

June 9. Comet's brightness decreasing. Appeared as a hazy disk about 2′ in diameter.

July 3. Stellar and faint. Moonlight.

July 5. Small, diffuse circular envelope.

July 6. Nucleus very faint. Wind and clouds.

July 8. No change in appearance of the 6th.

July 9. Brighter by half a magnitude than on the 8th. Neither tail nor envelope.

July 10. No change in appearance, or brightness. Seeing excellent.

July 12. Hazy. Comet growing brighter.

NEW ASTEROIDS.

Prof. Kreutz has communicated the discovery of three more asteroids by Mr. Charlois at Nice.

				α	δ	Daily Motion
			h m	h m s	° ′ ″	
1893 *AF*	12M	Aug. 11	13 19.6 Nice M.T.	21 27 3.2	—14 1 16	—48s in α, and 5′ southward.
AG	11M	17	9 46.8 "	22 9 58.2	— 5 2 27	—36s in α, and 5′ southward.
AH	10M	19	9 44.4 "	22 46 40.9	— 1 22 28	—60s in α, and 1′ northward.

CORRIGENDA.

Vol. XII, p. 162, col. 1, Eq. diam. of *Jupiter*, Oct. 28, for 48″.89 put 49″.89.

p. 173, col. 1, line —15, in second term, for 0°.502 put $\frac{1}{0^{\circ}.502}$

No. 302, p. 124, col. 1, line 13, for ⅃u put ⅃μ; and line 17, for ⅃n put ⅃ω.

p. 124, col. 2, and p. 125, col. 1, in the Elements, for u put μ, and omit (″) from the logarithm.

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THEORETICAL INEQUALITIES OF LONG PERIOD IN THE MOTIONS OF THE *EARTH, MARS, JUPITER* AND THE *MOON*,

BY JOHN N. STOCKWELL.

1. During the summer of 1892 I was engaged in a study of the conjunctions of the planets: and a curious mistake in calculation led to the detection of some theoretical inequalities of long period in the motions of the *Earth, Mars* and *Jupiter*, which, I believe have never before been computed. In preparing a table of the elongations of *Mars* from the sun at equidistant intervals of time, I was surprised to find that it required about 408 days for the elongation to increase from 0° to 180°; whereas, I knew that the interval should be only 390 days. In looking for the origin of this discrepancy I found that I had accidentally copied the difference of the mean motions of *Mars* and *Jupiter*, instead of the difference of the mean motions of the *Earth* and *Mars*, in preparing the arguments of the table. It then occurred to me that possibly there might be some interesting relations between the mean motions of these three planets, which would give rise to perturbations in their motions, and whose magnitude and laws were as yet undiscovered. I therefore decided to investigate further the question of the existence of such inequalities.

Now the mean daily motion of the *Earth* minus the mean daily motion of *Mars* is equal to 1661″.674 199; while the mean motion of *Mars* minus the mean motion of *Jupiter* is equal to 1587″.390 33. The difference of these two numbers is 74″.283 866; which would be the daily variation of the argument of the inequalities, whatever their magnitude might be. The inequalities therefore have a period of 17446.6 days, or 47.766 15 Julian years: and the inequalities would depend on the argument, *the mean longitude of the Earth, minus twice the mean longitude of Mars, plus the mean longitude of Jupiter.*

Now inequalities of the above form can arise only from terms of the order of the square of the disturbing forces; but since they are evidently independent of the eccentricities and inclinations of the orbits, their computation is not excessively laborious: and as they depend wholly on the masses and mean motions, it would seem that they might be of sensible magnitude. We shall find, however, that they are too small to be detected by observation; yet it has been thought best to publish an abstract of the investigation, as a contribution to theoretical astronomy: although of no practical importance in the theories of the motions of those planets.

2. In this investigation we shall designate the mean motions of the three planets, the *Earth, Mars* and *Jupiter*, by the letters n'', n''' and n^{iv}, respectively: their mean distances from the sun by a'', a''' and a^{iv}; their mean longitudes by $n''t$, $n'''t$ and $n^{\text{iv}}t$: their true longitudes by v'', v''' and v^{iv}; their distances from the sun by r'', r''' and r^{iv}; and their masses by m'', m''' and m^{iv}. The functions R, on which the perturbations depend, will then be given by the equations

$$\left.\begin{aligned} R'' = {} & \frac{m''' r'' r''' \cos(v''-v''')}{r'''^{3}} - \frac{m'''}{\left\{r''^{2}-2r''r'''\cos(v''-v''')+r'''^{2}\right\}^{1/2}} \\ & + \frac{m^{\text{iv}} r'' r^{\text{iv}} \cos(v''-v^{\text{iv}})}{r^{\text{iv}\,3}} - \frac{m^{\text{iv}}}{\left\{r''^{2}-2r''r^{\text{iv}}\cos(v''-v^{\text{iv}})+r^{\text{iv}\,2}\right\}^{1/2}} \end{aligned}\right\} \quad (1)$$

$$\left.\begin{aligned} R''' = {} & \frac{m'' r'' r''' \cos(v'''-v'')}{r''^{3}} - \frac{m''}{\left\{r''^{2}-2r''r'''\cos(v'''-v'')+r'''^{2}\right\}^{1/2}} \\ & + \frac{m^{\text{iv}} r''' r^{\text{iv}} \cos(v'''-v^{\text{iv}})}{r^{\text{iv}\,3}} - \frac{m^{\text{iv}}}{\left\{r'''^{2}-2r'''r^{\text{iv}}\cos(v'''-v^{\text{iv}})+r^{\text{iv}\,2}\right\}^{1/2}} \end{aligned}\right\} \quad (2)$$

$$\left.\begin{aligned} R^{\text{iv}} = {} & \frac{m'' r'' r^{\text{iv}} \cos(v^{\text{iv}}-v'')}{r''^{3}} - \frac{m''}{\left\{r''^{2}-2r''r^{\text{iv}}\cos(v^{\text{iv}}-v'')+r^{\text{iv}\,2}\right\}^{1/2}} \\ & + \frac{m''' r''' r^{\text{iv}} \cos(v^{\text{iv}}-v''')}{r'''^{3}} - \frac{m'''}{\left\{r'''^{2}-2r'''r^{\text{iv}}\cos(v^{\text{iv}}-v''')+r^{\text{iv}\,2}\right\}^{1/2}} \end{aligned}\right\} \quad (3)$$

The perturbations depend on the partial differential coefficients of these functions taken with respect to the coordinates r and v; and since the required inequalities are independent of the eccentricities, we may put $r''=a''$, $v''=n''t$, $r'''=a'''$, &c., in the developments. We shall now put for abridgement,

$$a''\div a'''=\alpha,\qquad a''\div a^{\text{iv}}=\alpha',\qquad a'''\div a^{\text{iv}}=\alpha''\,; \qquad (4)$$

$$n''t-n'''t=\theta,\qquad n''t-n^{\text{iv}}t=\theta',\qquad n'''t-n^{\text{iv}}t=\theta'' \qquad (5)$$

If we now take the partial differential coefficients of the forces R'', R''' and R^{iv}, with respect to the coordinates, and make the necessary substitutions, we shall find,

$$(6)\quad \left(\frac{dR''}{dr''}\right)=\frac{m'''}{a''^2}\alpha^2\left\{\cos\theta+(\alpha-\cos\theta)(1+\alpha^2-2\alpha\cos\theta)^{-3/2}\right\}+\frac{m^{\text{iv}}}{a''^2}\alpha'^2\left\{\cos\theta'+(\alpha'-\cos\theta')(1+\alpha'^2-2\alpha'\cos\theta')^{-3/2}\right\}$$

$$(7)\quad \left(\frac{dR''}{dv''}\right)=\frac{m'''}{a''}\alpha^2\sin\theta\left\{-1+(1+\alpha^2-2\alpha\cos\theta)^{-3/2}\right\}+\frac{m^{\text{iv}}}{a''}\alpha'^2\sin\theta'\left\{-1+(1+\alpha'^2-2\alpha'\cos\theta')^{-3/2}\right\}$$

$$(8)\quad \left(\frac{dR'''}{dr'''}\right)=\frac{m''}{a'''^2}\frac{1}{\alpha^2}\left\{\cos\theta+\alpha^2(1-\alpha\cos\theta)(1+\alpha^2-2\alpha\cos\theta)^{-3/2}\right\}$$
$$+\frac{m^{\text{iv}}}{a'''^2}\alpha''^2\left\{\cos\theta''+(\alpha''-\cos\theta'')(1+\alpha''^2-2\alpha''\cos\theta'')^{-3/2}\right\}$$

$$(9)\quad \left(\frac{dR'''}{dv'''}\right)=\frac{m''}{a'''}\alpha\sin\theta\left\{\frac{1}{\alpha^3}-(1+\alpha^2-2\alpha\cos\theta)^{-3/2}\right\}+\frac{m^{\text{iv}}}{a'''}\alpha''^2\sin\theta''\left\{(1+\alpha''^2-2\alpha''\cos\theta'')^{-3/2}-1\right\}$$

$$(10)\quad \left(\frac{dR^{\text{iv}}}{dr^{\text{iv}}}\right)=\frac{m''}{a^{\text{iv}2}}\frac{1}{\alpha'^2}\left\{\cos\theta'+\alpha'^2\{1-\alpha'\cos\theta'\}\{1+\alpha'^2-2\alpha'\cos\theta'\}^{-3/2}\right\}$$
$$+\frac{m'''}{a^{\text{iv}2}}\frac{1}{\alpha''^2}\left\{\cos\theta''+\alpha''^2\{1-\alpha''\cos\theta''\}\{1+\alpha''^2-2\alpha''\cos\theta''\}^{-3/2}\right\}$$

$$(11)\quad \left(\frac{dR^{\text{iv}}}{dv^{\text{iv}}}\right)=\frac{m''}{a^{\text{iv}}}\frac{1}{\alpha'^2}\sin\theta'\left\{1-\alpha'^3\{1+\alpha'^2-2\alpha'\cos\theta'\}^{-3/2}\right\}+\frac{m'''}{a^{\text{iv}}}\frac{1}{\alpha''^2}\sin\theta''\left\{1-\alpha''^3\{1+\alpha''^2-2\alpha''\cos\theta''\}^{-3/2}\right\}$$

These expressions enable us to determine the perturbations of the longitude and radius vector arising from the first power of the disturbing forces; but since the proposed inequalities are of the order of the square of the disturbing forces, we must find the increments to these forces which arise from the first power of the disturbing forces. Now, since these forces are functions of r and v, their variations will be functions of δr and δv; and in the further development of the subject we shall put for abridgement,

$$\left.\begin{aligned}A&=\{1+\alpha^2-2\alpha\cos\theta\}^{-3/2}\\ A'&=\{1+\alpha'^2-2\alpha'\cos\theta'\}^{-3/2}\\ A''&=\{1+\alpha''^2-2\alpha''\cos\theta''\}^{-3/2}\end{aligned}\right\}\qquad(12)$$

$$\left.\begin{aligned}A_1&=\{1+\alpha^2-2\alpha\cos\theta\}^{-5/2}\\ A_1'&=\{1+\alpha'^2-2\alpha'\cos\theta'\}^{-5/2}\\ A_1''&=\{1+\alpha''^2-2\alpha''\cos\theta''\}^{-5/2}\end{aligned}\right\}\qquad(13)$$

3. By means of these quantities, equations (6–11), together with their derivative functions may be reduced to the following:

$$(14)\qquad \left(\frac{dR''}{dr''}\right)=\frac{m'''}{a''^2}\alpha^2\left\{\cos\theta+\{\alpha-\cos\theta\}A\right\}+\frac{m^{\text{iv}}}{a''^2}\alpha'^2\left\{\cos\theta'+\{\alpha'-\cos\theta'\}A'\right\}$$

$$(15)\qquad \left(\frac{dR''}{dv''}\right)=\frac{m'''}{a''}\alpha^2\sin\theta\left\{A-1\right\}+\frac{m^{\text{iv}}}{a''}\alpha'^2\sin\theta'\left\{A'-1\right\}$$

$$(16)\qquad \left(\frac{dR'''}{dr'''}\right)=\frac{m''}{a'''^2}\left\{\frac{1}{\alpha^2}\cos\theta+\{1-\alpha\cos\theta\}A\right\}+\frac{m^{\text{iv}}}{a'''^2}\left\{\alpha''^2\cos\theta''+\alpha''^2\{\alpha''-\cos\theta''\}A''\right\}$$

$$(17)\qquad \left(\frac{dR'''}{dv'''}\right)=\frac{m''}{a'''}\alpha\sin\theta\left\{\frac{1}{\alpha^3}-A\right\}+\frac{m^{\text{iv}}}{a'''}\alpha''^2\sin\theta''\left\{A''-1\right\}$$

$$(18)\qquad \left(\frac{dR^{\text{iv}}}{dr^{\text{iv}}}\right)=\frac{m''}{a^{\text{iv}2}}\left\{\frac{1}{\alpha'^2}\cos\theta'+\{1-\alpha'\cos\theta'\}A'\right\}+\frac{m'''}{a^{\text{iv}2}}\left\{\frac{1}{\alpha''^2}\cos\theta''+\{1-\alpha''\cos\theta''\}A''\right\}$$

$$(19)\qquad \left(\frac{dR^{\text{iv}}}{dv^{\text{iv}}}\right)=\frac{m''}{a^{\text{iv}}}\frac{1}{\alpha'^2}\sin\theta'\left\{1-\alpha'^3A'\right\}+\frac{m'''}{a^{\text{iv}}}\frac{1}{\alpha''^2}\sin\theta''\left\{1-\alpha''^3A''\right\}$$

$$\begin{aligned}\delta\left(\frac{dR''}{dr''}\right) = {} & \frac{m'''}{a''^3}\alpha^3\left\{A-3\{\alpha-\cos\theta\}^2A_1\right\}\delta r'' + \frac{m'''}{a''^2}\alpha^2\sin\theta\left\{A-1+3\{\alpha\cos\theta-\alpha^2\}A_1\right\}\delta v'' \\ & + \frac{m'''}{a''^3}\alpha^3\left\{3\{\cos\theta-\alpha\}\{1-\alpha\cos\theta\}A_1-\cos\theta\{2+A\}\right\}\delta r''' + \frac{m'''}{a''^2}\alpha^2\sin\theta\left\{1-A+3\{\alpha^2-\alpha\cos\theta\}A_1\right\}\delta v''' \\ & + \frac{m^{\mathrm{iv}}}{a''^3}\alpha'^3\left\{A'-3\{\alpha'-\cos\theta'\}^2A_1'\right\}\delta r'' + \frac{m^{\mathrm{iv}}}{a''^2}\alpha'^2\sin\theta'\left\{A'-1+3\{\alpha'\cos\theta'-\alpha'^2\}A_1'\right\}\delta v'' \\ & + \frac{m^{\mathrm{iv}}}{a''^3}\alpha'^3\left\{3\{\cos\theta'-\alpha'\}\{1-\alpha'\cos\theta'\}A_1'-\cos\theta'\{2+A'\}\right\}\delta r^{\mathrm{iv}} + \frac{m^{\mathrm{iv}}}{a''^2}\alpha'^2\sin\theta'\left\{1-A'+3\{\alpha'^2-\alpha'\cos\theta'\}A_1'\right\}\delta v^{\mathrm{iv}}\end{aligned}\tag{20}$$

$$\begin{aligned}\delta\left(\frac{dR''}{dv''}\right) = {} & \frac{m'''}{a''^2}\alpha^2\sin\theta\left\{A-1+3\{\alpha\cos\theta-\alpha^2\}A_1\right\}\delta r'' + \frac{m'''}{a''}\alpha^2\left\{(A-1)\cos\theta-3\alpha\sin^2\theta A_1\right\}\delta v'' \\ & + \frac{m'''}{a''^2}\alpha^3\sin\theta\left\{2+A+3\{\alpha\cos\theta-1\}A_1\right\}\delta r''' + \frac{m'''}{a''}\alpha^2\left\{\{1-A\}\cos\theta+3\alpha\sin^2\theta A_1\right\}\delta v''' \\ & + \frac{m^{\mathrm{iv}}}{a''^2}\alpha'^2\sin\theta'\left\{A'-1+3\{\alpha'\cos\theta'-\alpha'^2\}A_1'\right\}\delta r'' + \frac{m^{\mathrm{iv}}}{a''}\alpha'^2\left\{\{A'-1\}\cos\theta'-3\alpha'\sin^2\theta' A_1'\right\}\delta v'' \\ & + \frac{m^{\mathrm{iv}}}{a''^2}\alpha'^3\sin\theta'\left\{2+A'+3\{\alpha'\cos\theta'-1\}A_1'\right\}\delta r^{\mathrm{iv}} + \frac{m^{\mathrm{iv}}}{a''}\alpha'^2\left\{\{1-A'\}\cos\theta'+3\alpha'\sin^2\theta' A_1'\right\}\delta v^{\mathrm{iv}}\end{aligned}\tag{21}$$

$$\begin{aligned}\delta\left(\frac{dR'''}{dr'''}\right) = {} & \frac{m''}{a'''^3}\left\{A-3\{1-\alpha\cos\theta\}^2A_1\right\}\delta r''' + \frac{m''}{a'''^2}\alpha\sin\theta\left\{\frac{1}{\alpha^3}-A+3\{1-\alpha\cos\theta\}A_1\right\}\delta v''' \\ & + \frac{m''}{a'''^3}\left\{3\{\alpha\cos\theta-1\}\{\alpha-\cos\theta\}A_1-\left(\frac{2}{\alpha^3}+A\right)\cos\theta\right\}\delta r'' + \frac{m''}{a'''^2}\alpha\sin\theta\left\{3\{\alpha\cos\theta-1\}A_1+A-\frac{1}{\alpha^3}\right\}\delta v'' \\ & + \frac{m^{\mathrm{iv}}}{a'''^3}\alpha''^3\left\{A''-3\{\alpha''-\cos\theta''\}^2A_1''\right\}\delta r''' + \frac{m^{\mathrm{iv}}}{a'''^2}\alpha''^2\sin\theta''\left\{A''-1+3\{\alpha''\cos\theta''-\alpha''^2\}A_1''\right\}\delta v''' \\ & + \frac{m^{\mathrm{iv}}}{a'''^3}\alpha''^3\left\{3\{\cos\theta''-\alpha''\}\{1-\alpha''\cos\theta''\}A_1''-\{2+A''\}\cos\theta''\right\}\delta r^{\mathrm{iv}} + \frac{m^{\mathrm{iv}}}{a'''^2}\alpha''^2\sin\theta''\left\{1-A''+3\{\alpha''^2-\alpha''\cos\theta''\}A_1''\right\}\delta v^{\mathrm{iv}}\end{aligned}\tag{22}$$

$$\begin{aligned}\delta\left(\frac{dR'''}{dv'''}\right) = {} & \frac{m''}{a'''^2}\alpha\sin\theta\left\{\frac{1}{\alpha^3}-A+3\{1-\alpha\cos\theta\}A_1\right\}\delta r''' + \frac{m''}{a'''}\alpha\left\{\left(A-\frac{1}{\alpha^3}\right)\cos\theta-3\alpha\sin^2\theta A_1\right\}\delta v''' \\ & + \frac{m''}{a'''^2}\sin\theta\left\{3\{\alpha^2-\alpha\cos\theta\}A_1-\frac{2}{\alpha^3}-A\right\}\delta r'' + \frac{m''}{a'''}\alpha\left\{\left(\frac{1}{\alpha^3}-A\right)\cos\theta+3\alpha\sin^2\theta A_1\right\}\delta v'' \\ & + \frac{m^{\mathrm{iv}}}{a'''^2}\alpha''\sin\theta''\left\{A''-1+3\{\alpha''\cos\theta''-\alpha''^2\}A_1''\right\}\delta r''' + \frac{m^{\mathrm{iv}}}{a'''}\alpha''^2\left\{\{A''-1\}\cos\theta''-3\alpha''\sin^2\theta'' A_1''\right\}\delta v''' \\ & + \frac{m^{\mathrm{iv}}}{a'''^2}\alpha''^3\sin\theta''\left\{2+A''+3\{\alpha''\cos\theta''-1\}A_1''\right\}\delta r^{\mathrm{iv}} + \frac{m^{\mathrm{iv}}}{a'''}\alpha''^2\left\{\{1-A''\}\cos\theta''+3\alpha''\sin^2\theta'' A_1''\right\}\delta v^{\mathrm{iv}}\end{aligned}\tag{23}$$

$$\begin{aligned}\delta\left(\frac{dR^{\mathrm{iv}}}{dr^{\mathrm{iv}}}\right) = {} & \frac{m''}{a^{\mathrm{iv}\,3}}\left\{A'-3\{1-\alpha'\cos\theta'\}^2A_1'\right\}\delta r^{\mathrm{iv}} + \frac{m''}{a^{\mathrm{iv}\,2}}\alpha'\sin\theta'\left\{\frac{1}{\alpha'^3}-A'+3\{1-\alpha'\cos\theta'\}A_1'\right\}\delta v^{\mathrm{iv}} \\ & + \frac{m''}{a^{\mathrm{iv}\,3}}\left\{3\{\alpha'\cos\theta'-1\}\{\alpha'-\cos\theta'\}A_1'-\left(\frac{2}{\alpha'^3}+A'\right)\cos\theta'\right\}\delta r'' + \frac{m''}{a^{\mathrm{iv}\,2}}\alpha'\sin\theta'\left\{A'-\frac{1}{\alpha'^3}+3\{\alpha'\cos\theta'-1\}A_1'\right\}\delta v'' \\ & + \frac{m'''}{a^{\mathrm{iv}\,3}}\left\{A''-3\{1-\alpha''\cos\theta''\}^2A_1''\right\}\delta r^{\mathrm{iv}} + \frac{m'''}{a^{\mathrm{iv}}}\alpha''\sin\theta''\left\{\frac{1}{\alpha''^3}-A''+3\{1-\alpha''\cos\theta''\}A_1''\right\}\delta v^{\mathrm{iv}} \\ & + \frac{m'''}{a^{\mathrm{iv}\,3}}\left\{3\{\alpha''\cos\theta''-1\}\{\alpha''-\cos\theta''\}A_1''-\left(\frac{2}{\alpha''^3}+A''\right)\cos\theta''\right\}\delta r''' + \frac{m'''}{a^{\mathrm{iv}\,2}}\alpha''\sin\theta''\left\{A''-\frac{1}{\alpha''^3}+3\{\alpha''\cos\theta''-1\}A_1''\right\}\delta v'''\end{aligned}\tag{24}$$

$$\begin{aligned}\delta\left(\frac{dR^{\mathrm{iv}}}{dv^{\mathrm{iv}}}\right) = {} & \frac{m''}{a^{\mathrm{iv}\,2}}\alpha'\sin\theta'\left\{\frac{1}{\alpha'^3}-A'+3\{1-\alpha'\cos\theta'\}A_1'\right\}\delta r^{\mathrm{iv}} + \frac{m''}{a^{\mathrm{iv}}}\alpha'\left\{\left(A'-\frac{1}{\alpha'^3}\right)\cos\theta'-3\alpha'\sin^2\theta' A_1'\right\}\delta v^{\mathrm{iv}} \\ & + \frac{m''}{a^{\mathrm{iv}\,2}}\sin\theta'\left\{3\{\alpha'^2-\alpha'\cos\theta'\}A_1'-\frac{2}{\alpha'^3}-A'\right\}\delta r'' + \frac{m''}{a^{\mathrm{iv}}}\alpha'\left\{\left(\frac{1}{\alpha'^3}-A'\right)\cos\theta'+3\alpha'\sin^2\theta' A_1'\right\}\delta v'' \\ & + \frac{m'''}{a^{\mathrm{iv}\,2}}\alpha''\sin\theta''\left\{\frac{1}{\alpha''^3}-A''+3\{1-\alpha''\cos\theta''\}A_1''\right\}\delta r^{\mathrm{iv}} + \frac{m'''}{a^{\mathrm{iv}}}\alpha''\left\{\left(A''-\frac{1}{\alpha''^3}\right)\cos\theta''-3\alpha''\sin^2\theta'' A_1''\right\}\delta v^{\mathrm{iv}} \\ & + \frac{m'''}{a^{\mathrm{iv}\,2}}\sin\theta''\left\{3\{\alpha''^2-\alpha''\cos\theta''\}A_1''-\frac{2}{\alpha''^3}-A''\right\}\delta r''' + \frac{m'''}{a^{\mathrm{iv}}}\alpha''\left\{\left(\frac{1}{\alpha''^3}-A''\right)\cos\theta''+3\alpha''\sin^2\theta'' A_1''\right\}\delta v'''\end{aligned}\tag{25}$$

4. The quantities A, A', &c., given by equations (12) and (13), may be developed in infinite series of terms depending on the cosines of $\theta, \theta', \theta''$, and of their multiples; the coefficients of these cosines being constant, and functions of a, a', a''. If we substitute the values of the mean distances of the planets *Earth*, *Mars* and *Jupiter*, in equations (4), we shall find,

$$
\left\{
\begin{array}{lll}
a & = 0.6363009 & \log 9.8171030 \\
a' & = 0.1922042 & \log 9.2837630 \\
a'' & = 0.2928600 & \log 9.4666601
\end{array}
\right. \tag{26}
$$

These give the following quantities which are required in the preceding equations,

$$
\begin{array}{ll}
a^2 = 0.4307309 & a^3 = 0.2826890 \\
a'^2 = 0.03694248 & a'^3 = 0.00710050 \\
a''^2 = 0.08576700 & a''^3 = 0.02511772
\end{array}
$$

$$
\begin{aligned}
1 &= 3.537455\, a^3 \\
1 &= 140.8351\, a'^3 \\
1 &= 39.81253\, a''^3
\end{aligned} \tag{27}
$$

The above values of a, a' and a'', being substituted in equations (12) and (13), will reduce them to the following:

$$A = 3.428180 + 5.727912 \cos\theta + 4.404531 \cos 2\theta + 3.25594 \cos 3\theta + 2.35116 \cos 4\theta + \&c.; \tag{28}$$

$$A' = 1.088171 + 0.618814 \cos\theta' + 0.147979 \cos 2\theta' + 0.033100 \cos 3\theta' + 0.007123 \cos 4\theta' + \&c.; \tag{29}$$

$$A'' = 1.222221 + 1.039763 \cos\theta'' + 0.376437 \cos 2\theta'' + 0.127897 \cos 3\theta'' + 0.0419958 \cos 4\theta'' + \&c. \tag{30}$$

$$A_1 = 19.00186 + 36.20041 \cos\theta + 32.18531 \cos 2\theta + 27.25225 \cos 3\theta + 22.26328 \cos 4\theta + \&c.; \tag{31}$$

$$A_1' = 1.259346 + 1.132635 \cos\theta' + 0.372314 \cos 2\theta' + 0.106102 \cos 3\theta' + 0.027884 \cos 4\theta' + \&c.; \tag{32}$$

$$A_1'' = 1.709154 + 2.163226 \cos\theta'' + 1.051391 \cos 2\theta'' + 0.449381 \cos 3\theta'' + 0.177956 \cos 4\theta'' + \&c. \tag{33}$$

If we substitute these values in equations (14–25), and retain only the useful terms, they will become,

$$\left(\frac{dR''}{dr''}\right) = \frac{m'''}{a''^2}\left\{-0.375257 \cos\theta - 0.6896985 \cos 2\theta\right\} + \frac{m^{\text{iv}}}{a''^2}\left\{-0.00159669 \cos\theta' - 0.01099094 \cos 2\theta'\right\} \tag{34}$$

$$\left(\frac{dR''}{dv''}\right) = \frac{m'''}{a''}\left\{0.0973082 \sin\theta + 0.5323773 \sin 2\theta\right\} + \frac{m^{\text{iv}}}{a''}\left\{0.000523918 \sin\theta' + 0.01081887 \sin 2\theta'\right\} \tag{35}$$

$$\left(\frac{dR'''}{dr'''}\right) = \frac{m''}{a'''^2}\left\{4.354280 \cos\theta + 1.456476 \cos 2\theta\right\} + \frac{m^{\text{iv}}}{a'''^2}\left\{-0.00908567 \cos\theta'' - 0.04061810 \cos 2\theta''\right\} \tag{36}$$

$$\left(\frac{dR'''}{dv'''}\right) = \frac{m''}{a'''}\left\{1.517066 \sin\theta - 0.811179 \sin 2\theta\right\} + \frac{m^{\text{iv}}}{a'''}\left\{0.002916335 \sin\theta'' + 0.0391040 \sin 2\theta''\right\} \tag{37}$$

$$\left(\frac{dR^{\text{iv}}}{dr^{\text{iv}}}\right) = \frac{m''}{a^{\text{iv}\,2}}\left\{27.46455 \cos\theta' + 0.085329 \cos 2\theta'\right\} + \frac{m'''}{a^{\text{iv}\,2}}\left\{12.286202 \cos\theta'' + 0.205456 \cos 2\theta''\right\} \tag{38}$$

$$\left(\frac{dR^{\text{iv}}}{dv^{\text{iv}}}\right) = \frac{m''}{a^{\text{iv}}}\left\{26.87418 \sin\theta' - 0.05628836 \sin 2\theta'\right\} + \frac{m'''}{a^{\text{iv}}}\left\{11.35668 \sin\theta'' - 0.1335246 \sin\theta''\right\} \tag{39}$$

$$
\begin{aligned}
\delta\left(\frac{dR''}{dr''}\right) = {} & \frac{m'''}{a''^3}\left\{-0.704619 - 1.341283 \cos\theta - 1.620117 \cos 2\theta\right\}\delta r'' + \frac{m'''}{a''^2}\left\{+0.375234 \sin\theta + 1.39230 \sin 2\theta\right\}\delta v'' \\
& + \frac{m'''}{a''^3}\left\{+0.809606 + 1.37282 \cos\theta + 1.968644 \cos 2\theta\right\}\delta r''' + \frac{m'''}{a''^2}\left\{-0.375234 \sin\theta - 1.39230 \sin 2\theta\right\}\delta v''' \\
& + \frac{m^{\text{iv}}}{a''^3}\left\{-0.00402287 - 0.00332111 \cos\theta' - 0.0116975 \cos 2\theta'\right\}\delta r'' \\
& \qquad + \frac{m^{\text{iv}}}{a''^2}\left\{+0.0015967 \sin\theta' + 0.0219818 \sin 2\theta'\right\}\delta v'' \\
& + \frac{m^{\text{iv}}}{a''^3}\left\{+0.00219694 + 0.000274711 \cos\theta' + 0.00647333 \cos 2\theta'\right\}\delta r^{\text{iv}} \\
& \qquad + \frac{m^{\text{iv}}}{a''^2}\left\{-0.0015967 \sin\theta' - 0.0219818 \sin 2\theta'\right\}\delta v^{\text{iv}}
\end{aligned} \tag{40}
$$

$$
\begin{aligned}
\delta\left(\frac{dR''}{dv''}\right) = {} & \frac{m'''}{a''^2}\left\{+0.375234 \sin\theta + 1.39230 \sin 2\theta\right\}\delta r'' + \frac{m'''}{a''}\left\{+0.0973193 \cos\theta + 1.06477 \cos 2\theta\right\}\delta v'' \\
& + \frac{m'''}{a''^2}\left\{-0.310162 \sin\theta - 1.25469 \sin 2\theta\right\}\delta r''' + \frac{m'''}{a''}\left\{-0.0973193 \cos\theta - 1.06477 \cos 2\theta\right\}\delta v''' \\
& + \frac{m^{\text{iv}}}{a''^2}\left\{+0.0015967 \sin\theta' + 0.0219818 \sin 2\theta'\right\}\delta r'' + \frac{m^{\text{iv}}}{a''}\left\{+0.00560925 \cos\theta' + 0.00244522 \cos 2\theta'\right\}\delta v'' \\
& + \frac{m^{\text{iv}}}{a''^2}\left\{-0.00040761 \sin\theta' - 0.00087810 \sin 2\theta'\right\}\delta r^{\text{iv}} + \frac{m^{\text{iv}}}{a''}\left\{-0.0056025 \cos\theta' - 0.00244522 \cos 2\theta'\right\}\delta v^{\text{iv}}
\end{aligned} \tag{41}
$$

$$\delta\left(\frac{dR'''}{dr'''}\right)=\frac{m''}{a'''^3}\Big\{-4.97674-8.56505\cos\theta-7.48318\cos2\theta\Big\}\delta r'''+\frac{m''}{a'''^2}\Big\{+4.35425\sin\theta+2.91293\sin2\theta\Big\}\delta v'''$$

$$(42)\qquad+\frac{m''}{a'''^3}\Big\{+2.86396-0.21861\cos\theta+6.96399\cos2\theta\Big\}\delta r''+\frac{m''}{a'''}\Big\{-4.35425\sin\theta-2.91293\sin2\theta\Big\}\delta v''$$

$$+\frac{m^{\rm iv}}{a'''^3}\Big\{-0.0168101-0.0199471\cos\theta''-0.0470452\cos2\theta''\Big\}\delta r'''$$

$$+\frac{m^{\rm iv}}{a'''^2}\Big\{+0.0090858\sin\theta''+0.0812378\sin2\theta''\Big\}\delta v'''$$

$$+\frac{m^{\rm iv}}{a'''^3}\Big\{+0.0130582+0.0111633\cos\theta''+0.0375684\cos2\theta''\Big\}\delta r^{\rm iv}$$

$$+\frac{m^{\rm iv}}{a'''^2}\Big\{-0.0090858\sin\theta''-0.0812378\sin2\theta''\Big\}\delta v^{\rm iv}$$

$$\delta\left(\frac{dR'''}{dv'''}\right)=\frac{m''}{a'''^2}\Big\{+4.35432\sin\theta+2.91294\sin2\theta\Big\}\delta r'''+\frac{m''}{a'''}\Big\{-1.517050\cos\theta+1.622373\cos2\theta\Big\}\delta v'''$$

$$+\frac{m''}{a'''^2}\Big\{-8.94608\sin\theta-3.23245\sin2\theta\Big\}dr''+\frac{m''}{a'''}\Big\{+1.517050\cos\theta-1.622373\cos2\theta\Big\}\delta v''$$

$$(43)\qquad+\frac{m^{\rm iv}}{a'''^2}\Big\{+0.0090858\sin\theta''+0.0812378\sin2\theta''\Big\}dr'''+\frac{m^{\rm iv}}{a'''}\Big\{+0.00291625\cos\theta''+0.0782080\cos2\theta''\Big\}\delta v'''$$

$$+\frac{m^{\rm iv}}{a'''^2}\Big\{-0.0035149\sin\theta''-0.0352429\sin2\theta''\Big\}\delta r^{\rm iv}+\frac{m^{\rm iv}}{a'''}\Big\{-0.00291625\cos\theta''-0.0782080\cos2\theta''\Big\}\delta v^{\rm iv}$$

$$\delta\left(\frac{dR^{\rm iv}}{dr^{\rm iv}}\right)=\frac{m''}{a^{\rm iv\,3}}\Big\{-2.116879-1.209185\cos\theta'-0.345884\cos2\theta'\Big\}\delta r^{\rm iv}+\frac{m''}{a^{\rm iv\,2}}\Big\{+27.46454\sin\theta'+0.1706553\sin2\theta'\Big\}\delta v^{\rm iv}$$

$$+\frac{m''}{a^{\rm iv\,3}}\Big\{+0.3094057-279.63154\cos\theta'+0.911672\cos2\theta'\Big\}\delta r''+\frac{m''}{a^{\rm iv\,2}}\Big\{-27.46454\sin\theta'-0.1706553\sin2\theta'\Big\}\delta v''$$

$$(44)\qquad+\frac{m'''}{a^{\rm iv\,3}}\Big\{-2.292189-1.969285\cos\theta''-0.848946\cos2\theta''\Big\}\delta r^{\rm iv}+\frac{m'''}{a^{\rm iv\,2}}\Big\{+12.28620\sin\theta''+0.4109138\sin2\theta''\Big\}\delta v^{\rm iv}$$

$$+\frac{m'''}{a^{\rm iv\,3}}\Big\{+0.519880-77.180618\cos\theta''+1.495695\cos2\theta''\Big\}\delta r'''+\frac{m'''}{a^{\rm iv\,2}}\Big\{-12.28620\sin\theta''-0.4109138\sin2\theta''\Big\}\delta v'''$$

$$\delta\left(\frac{dR^{\rm iv}}{dv^{\rm iv}}\right)=\frac{m''}{a^{\rm iv\,2}}\Big\{+27.46454\sin\theta'+0.1706553\sin2\theta'\Big\}\delta r^{\rm iv}+\frac{m''}{a^{\rm iv}}\Big\{-26.84770\cos\theta'+0.1125786\cos2\theta'\Big\}\delta v^{\rm iv}$$

$$+\frac{m''}{a^{\rm iv\,2}}\Big\{-282.7135\sin\theta'-0.5950284\sin2\theta'\Big\}\delta r''+\frac{m''}{a^{\rm iv}}\Big\{+26.84770\cos\theta'-0.1125786\cos2\theta'\Big\}\delta v''$$

$$(45)\qquad+\frac{m'''}{a^{\rm iv\,2}}\Big\{+12.28620\sin\theta''+0.4109138\sin2\theta''\Big\}\delta r^{\rm iv}+\frac{m'''}{a^{\rm iv}}\Big\{-10.86059\cos\theta''+0.267049\cos2\theta''\Big\}\delta v^{\rm iv}$$

$$+\frac{m'''}{a^{\rm iv\,2}}\Big\{-80.73100\sin\theta''-0.947191\sin2\theta''\Big\}\delta r'''+\frac{m'''}{a^{\rm iv}}\Big\{+10.86059\cos\theta''-0.267049\cos2\theta''\Big\}\delta v'''$$

5. The perturbations of the raidius vector and of the longitude, which are independent of the eccentricities and inclinations of the orbits, may be determined by means of the following equations: (46)

$$\frac{d\delta r}{dt}=an\cos nt\int\Big\{-a^2ndt\cos nt\left(\frac{dR}{dr}\right)+2a\,ndt\sin nt\left(\frac{dR}{dv}\right)\Big\}$$

$$-an\sin nt\int\Big\{a^2ndt\sin nt\left(\frac{dR}{dr}\right)+2a\,ndt\cos nt\left(\frac{dR}{dv}\right)\Big\}$$

$$\frac{d\delta v}{dt}=-\frac{1}{a^2}\int\left(\frac{dR}{dv}\right)dt-2\frac{n}{a}\delta r\qquad(47)$$

Equation (46) determines the value of δr, which is to be substituted in equation (47) for the determination of δv.

6. If we now substitute the values of θ, θ' and θ'', which are given by equations (5), in the expressions for the disturbing forces which are given by equations (34–39), and then substitute each pair of these forces in succession in equations (46) and (47), we shall find the following values for the perturbations arising from the first power of the disturbing forces.

$$\delta r''=a''m'''\Big\{+1.012993\cos\theta+14.88317\cos2\theta\Big\}\qquad(48)$$

$$+a''m^{\rm iv}\Big\{+0.01658206\cos\theta'-0.00968816\cos2\theta'\Big\}$$

$$\delta v''=m'''\Big\{-3.882432\sin\theta-31.17336\sin2\theta\Big\}\qquad(49)$$

$$+m^{\rm iv}\Big\{-0.03559258\sin\theta'+0.01380578\sin2\theta'\Big\}$$

$$\delta_{,}'''=a'''m''\Big\{-4.057696\cos\theta+1.130306\cos2\theta\Big\}\qquad(50)$$

$$+a'''m^{\rm iv}\Big\{+0.0518580\cos\theta''-0.0475462\cos2\theta''\Big\}$$

$$
\begin{aligned}
\delta v''' &= \phantom{a^{iv}}m''\left\{+11.16890\sin\theta - 1.544610\sin 2\theta\right\}\\
(51)\ &+ \phantom{a^{iv}}m^{iv}\left\{-0.1262719\sin\theta'' + 0.07031336\sin 2\theta''\right\}\\
\delta r^{iv} &= a^{iv}m''\left\{+0.1924818\cos\theta' + 0.000192204\cos 2\theta'\right\}\\
(52)\ &+ a^{iv}m'''\left\{+0.2947611\cos\theta'' + 0.00206563\cos 2\theta''\right\}\\
\delta v^{iv} &= \phantom{a^{iv}}m''\left\{+0.1923480\sin\theta' - 0.0001369726\sin 2\theta'\right\}\\
(53)\ &+ \phantom{a^{iv}}m'''\left\{+0.2921834\sin\theta'' - 0.001574605\sin 2\theta''\right\}
\end{aligned}
$$

7. The perturbations given by equations (48–53) are very nearly the same as were found by LAPLACE in the sixth book of the *Mécanique Céleste*; and if we now substitute them in equations (40–45), we shall obtain the expressions of the forces of the second order. Now equations (5) give

$$(54)\quad \theta - \theta'' = \theta' - 2\theta'' = 2\theta - \theta' = n''t - 2n'''t + n^{iv}t;$$

and as this is the only argument of long period, we may omit all except arguments of the form given in equation (54).

We shall therefore get the following reduced values of the required forces.

$$\delta\left(\frac{dR''}{dr''}\right) = \frac{m'''m^{iv}}{a''^2}\left\{\begin{aligned}&-0.01343240\cos(2\theta-\theta') - 0.02477778\cos(2\theta-\theta') + 0.05737470\cos(\theta-\theta'') + 0.02369075\cos(\theta-\theta'')\\ &-0.02471433\cos(2\theta-\theta') - 0.02488725\cos(2\theta-\theta') + 0.00000014762\cos(\theta'-2\theta'')\\ &+0.00000125709\cos(\theta'-2\theta'')\right\}\end{aligned} \qquad (55)$$

$$\delta\left(\frac{dR''}{dv''}\right) = \frac{m'''m^{iv}}{a''}\left\{\begin{aligned}&+0.01154361\sin(2\theta-\theta') + 0.01894896\sin(2\theta-\theta') - 0.01296270\sin(\theta-\theta'') - 0.00614434\sin(\theta-\theta'')\\ &-0.01188198\sin(2\theta-\theta') - 0.08746964\sin(2\theta-\theta') - 0.00000021903\sin(\theta'-2\theta'')\\ &-0.0000044162\sin(\theta'-2\theta'')\right\}\end{aligned} \qquad (56)$$

$$\delta\left(\frac{dR'''}{dr'''}\right) = \frac{m''m^{iv}}{a'''^2}\left\{\begin{aligned}&-0.2349305\cos(\theta-\theta'') - 0.2749097\cos(\theta-\theta'') + 0.03789394\cos(2\theta-\theta') + 0.05183936\cos(2\theta-\theta')\\ &+0.04046964\cos(\theta-\theta'') + 0.05073920\cos(\theta-\theta'') + 0.0123459\cos(\theta'-2\theta'')\\ &-0.00781296\cos(\theta'-2\theta'')\right\}\end{aligned} \qquad (57)$$

$$\delta\left(\frac{dR'''}{dv'''}\right) = \frac{m''m^{iv}}{a'''}\left\{\begin{aligned}&+0.1194345\sin(\theta-\theta'') - 0.09578038\sin(\theta-\theta'') - 0.01758910\sin(2\theta-\theta') - 0.02887220\sin(2\theta-\theta')\\ &+0.01843371\sin(\theta-\theta'') + 0.01628565\sin(\theta-\theta'') + 0.01158167\sin(\theta'-2\theta'')\\ &-0.007521577\sin(\theta'-2\theta'')\right\}\end{aligned} \qquad (58)$$

$$\delta\left(\frac{dR^{iv}}{dr^{iv}}\right) = \frac{m''m'''}{a^{iv\,2}}\left\{\begin{aligned}&-0.00124886\cos(\theta'-2\theta'') - 0.0216229\cos(\theta'-2\theta'') - 317.6980\cos(2\theta-\theta') + 428.0810\cos(2\theta-\theta')\\ &-0.08170334\cos(\theta'-2\theta'') + 0.0395192\cos(\theta'-2\theta'') + 45.85830\cos(\theta-\theta'')\\ &-68.61170\cos(\theta-\theta'')\right\}\end{aligned} \qquad (59)$$

$$\delta\left(\frac{dR^{iv}}{dv^{iv}}\right) = \frac{m''m'''}{a^{iv}}\left\{\begin{aligned}&+0.0283658\sin(\theta'-2\theta'') - 02113726\sin(\theta'-2\theta'') + 404.3661\sin(2\theta-\theta') - 418.4665\sin(2\theta-\theta')\\ &-0.0395467\sin(\theta'-2\theta'') + 0.02568317\sin(\theta'-2\theta'') - 47.96781\sin(\theta-\theta'')\\ &+60.65013\sin(\theta-\theta'')\right\}\end{aligned} \qquad (60)$$

By taking the sum of the coefficients in equations (55–60) and substituting the values of θ, θ' and θ'', we get the following values of the forces in the required form.

$$
\begin{aligned}
(61)\ \delta\left(\frac{dR''}{dr''}\right) &= \frac{m'''m^{iv}}{a''^2}(-0.00674363)\cos(n''t-2n'''t+n^{iv}t)\\
\delta\left(\frac{dR''}{dv''}\right) &= \frac{m'''m^{iv}}{a''}(-0.08797270)\sin(n''t-2n'''t+n^{iv}t)\\
(62)\ \delta\left(\frac{dR'''}{dr'''}\right) &= \frac{m''m^{iv}}{a'''^2}(-0.3243652)\cos(n''t-2n'''t+n^{iv}t)\\
\delta\left(\frac{dR'''}{dv'''}\right) &= \frac{m''m^{iv}}{a'''}(+0.1117526)\sin(n''t-2n'''t+n^{iv}t)\\
(63)\ \delta\left(\frac{dR^{iv}}{dr^{iv}}\right) &= \frac{m''m'''}{a^{iv\,2}}(+87.5646)\cos(n''t-2n'''t+n^{iv}t)\\
\delta\left(\frac{dR^{iv}}{dv^{iv}}\right) &= \frac{m''m'''}{a^{iv}}(-1.4241)\sin(n''t-2n'''t+n^{iv}t)
\end{aligned}
$$

8. These values are to be substituted in succession in equations (46) and (47), in place of $\left(\frac{dR}{dr}\right)$ and $\left(\frac{dR}{dv}\right)$, and we shall obtain

$$
\begin{aligned}
(64)\ \delta^2 r'' &= a''m'''m^{iv}\left\{-[0.9092583]\cos(n''t-2n'''t+n^{iv}t)\right\}\\
\delta^2 v'' &= m'''m^{iv}\left\{+[2.7592639]\sin(n''t-2n'''t+n^{iv}t)\right\}
\end{aligned}
$$

$$
\begin{aligned}
\delta^2 r''' &= a'''m''m^{iv}\left\{+[0.7788629]\cos(n''t-2n'''t+n^{iv}t)\right\} \quad (65)\\
\delta^2 v''' &= m''m^{iv}\left\{-[2.3676851]\sin(n''t-2n'''t+n^{iv}t)\right\}\\
\delta^2 r^{iv} &= a^{iv}m''m'''\left\{-[2.0250818]\cos(n''t-2n'''t+n^{iv}t)\right\} \quad (66)\\
\delta^2 v^{iv} &= m''m'''\left\{+[2.9191616]\sin(n''t-2n'''t+n^{iv}t)\right\}
\end{aligned}
$$

the numbers in brackets being logarithms.

If we now suppose the masses of the planets to be

$$
\left.
\begin{aligned}
m'' &= 1 \div 329630 &&\log 94.4819733\\
m''' &= 1 \div 3100000 &&\text{“}\ 93.5086383\\
m^{iv} &= 1 \div 1047.9 &&\text{“}\ 96.9796802
\end{aligned}
\right\} \qquad (67)
$$

the sun's mass being unity, we shall find

$$
\begin{aligned}
\delta^2 r'' &= -a''[91.3975768]\cos(n''t-2n'''t+n^{iv}t) && (68)\\
\delta^2 v'' &= +[93.2475824]\sin(n''t-2n'''t+n^{iv}t);\\
\delta^2 r''' &= +a''[92.4234134]\cos(n''t-2n'''t+n^{iv}t) && (69)\\
\delta^2 v''' &= -[93.8293386]\sin(n''t-2n'''t+n^{iv}t);\\
\delta^2 r^{iv} &= -a''[90.7319304]\cos(n''t-2n'''t+n^{iv}t && (70)\\
\delta^2 v^{iv} &= [90.9097732]\sin(n''t-2n'''t+n^{iv}t.
\end{aligned}
$$

If we suppose the sun's distance from the earth to be 93 000 000 miles, the maximum perturbations, depending on the above argument, become

$$(71)\qquad \begin{aligned} \delta^2 r'' &= \ 0.2323 \text{ miles} = 1226 \text{ feet} \\ \delta^2 v'' &= 16.45 \text{ miles} = 0''.0365 \\ \delta^2 r''' &= \ 2.4654 \text{ miles} = 13018 \text{ feet} \\ \delta^2 v''' &= 95.65 \text{ miles} = 0''.140 \\ \delta^2 r^{\text{iv}} &= \ 0.0501 \text{ miles} = 264.5 \text{ feet} \\ \delta^2 v^{\text{iv}} &= \ 0.393 \text{ miles} = 0''.000167 \end{aligned}$$

These quantities are too small to be detected by observation; yet they are interesting, for they show, what might have been expected from the form of the argument, that the mean motion of *Mars* is always *accelerated*, while the mean motions of the *Earth* and *Jupiter* are *retarded*; and *vice versa*.

9. It now only remains to determine the effect of the preceding inequality in the motion of the earth, upon the motion of the moon. The theory of the moon's motion contains the term,

$$(72)\qquad \left(\frac{dR}{dr}\right) = -\tfrac{1}{2}\, m'' \frac{r}{r''^{3}}$$

The variation of this with respect to r'', is,

$$(73)\qquad \delta\left(\frac{dR}{dr}\right) = +\tfrac{3}{2}\frac{m'' r}{r''^{4}}\delta r'' = \tfrac{3}{2}\frac{\bar{m}^2}{a^2 a''}\delta r''$$

and if we put, for abridgement,

$$n'' - 2n'' + n^{\text{iv}} = \alpha n = 0.001566017 n \qquad (74)$$

equation (64) will give

$$\delta r'' = -a'' m''' m^{\text{iv}}\, [0.9092583] \cos \alpha n t \qquad (75)$$

n denoting the moon's mean motion. Therefore we shall have

$$\delta\left(\frac{dR}{dr}\right) = -\frac{\bar{m}^2}{a^2}\, m''' m^{\text{iv}}\, [1.0853496] \cos \alpha n t \qquad (76)$$

Then equations (49) and (50) will give

$$\delta r = [1.0853496]\, a \frac{\bar{m}^2 m''' m^{\text{iv}}}{1-\alpha^2} \cos \alpha n t \qquad (77)$$

$$\delta v = -[1.3863796]\, \frac{m^2 m''' m^{\text{iv}}}{\alpha(1-\alpha^2)} \sin \alpha n t \qquad (78)$$

Or finally, by reducing to numbers

$$\left.\begin{aligned} \delta r &= -[89.32148]\, a \cos \alpha n t \\ \delta v &= [97.74214] \sin \alpha n t \end{aligned}\right\} \qquad (79)$$

The greatest variation of the moon's distance from the earth would therefore amount to only 0.316 inches, while its longitude would be changed by 0''.005523, or 33.64 feet in a period of about twelve years.

Cleveland, 1893 *Aug*. 31.

NEW DETERMINATION OF THE ORBIT OF THE DOUBLE STAR F. 70 *OPHIUCHI*,

By Professor W. SCHUR.

As I have already announced on different occasions, I am engaged upon a new determination of the orbit of 70 *Ophiuchi*. My calculations, employing all attainable observations, including the recent ones by Professor HALL, kindly sent to me for the purpose, together with my own observations up to the present time, give the following elements:

Passage of periastron,	T	1808.025
Position-angle of node,	☊	121° 23'
Inclination,	i	59 56
Angle between node and projection of periastr.,	λ	168 24
Eccentricity,	e	0.4759
Annual motion,	n	—4°.0728
Semi-axis,	a	4''.69
Time of revolution,	U	88.39 yrs.

The motion at the present time will be seen by the following table.

		°		''
1885	$p =$	31.8	$\rho =$	2.01
86		21.6		1.94
87		11.0		1.92
88		0.5		1.94
89		350.3		2.01
90		341.0		2.10
91		332.5		2.22
92		324.9		2.32
93		317.8		2.41
94		311.3		2.48
1895		304.9		2.50

Perhaps the dates may require small alterations when a further approximation of the systematic corrections of the observations is taken into account; but the elements will be very near the truth. The details of the calculation and of the researches concerning the systematic corrections will be published in a short time.

Göttingen, 1893 *September*.

THE PERIOD OF THE FIFTH SATELLITE OF *JUPITER*,

By E. E. BARNARD.

The satellite was first seen, at this opposition of *Jupiter*, on September 3; but, on account of the low altitude of the planet, the measures were not very satisfactory. On September 15, however, it was well seen before eastern elongation, and 21 measures of it were secured with the 36-inch. Though fairly well seen, the satellite was faint.

From these measures I have deduced the time of eastern elongation independently from each observation by the formula,

$$T = t \pm \frac{1}{0^\circ.502}\cos^{-1}\frac{\delta}{\Delta}$$

δ = measured distance, Δ = the apparent elongation-distance, derived from last year's observations, t being the observation-time, and $0^\circ.502$ the angular motion of the satellite in its orbit in one minute of time.

The indiscriminate mean of these gives for the east elongation at 1893 September 15, $17^h\ 36^m.9$ Standard Pacific Time, which is eight hours slow of Greenwich.

This makes the satellite some eight minutes slow of Marth's ephemeris in *M.N.*, Vol. LIII, No. 8.

Combining this with the elongation computed from observations 1892 September 10 ($12^h\ 47^m.5$ St. P. T.), and correcting for aberration and parallax, I get the following period.

$$P = 11^h\ 57^m\ 22^s.56.$$

From observations extending over only three months, I got last year

$$P = 11^h\ 57^m\ 23^s.06 \text{ (see } A.J.\ 286).$$

In the above number of the *Monthly Notices*, Mr. Marth, from my observations last year, derived

$$P = 11^h\ 57^m\ 21^s.88.$$

The present determination of the period is $0^s.50$ less than my former value, and $0^s.68$ greater than Marth's.

The measured equatorial diameter was 44″.34 corrected for phase, by the aid of Marth's ephemeris, *M.N.*, Vol. LIII, No. 8. The half value 22″.17 has been applied to the measures from the limb to get the distance from the center of *Jupiter*.

MICROMETER MEASURES.

1893	Standard Pacific Time 8h slow of Gr.	Rev. of Mic. Ser. Coincid. = 10r.107	Obs'd Δ from f. Limb	Δ from center	Computed East Elongation
	h m s	r	″	″	h m
Sept. 15	16 14 50	8.253	18.36	40.53	17 40.0
15	16 5	8.139	19.49	41.66	17 37.8
15	18 46	8.010	20.76	42.93	17 36.4
15	20 40	8.012	20.74	42.91	17 38.4
15	22 20	7.938	21.48	43.65	17 37.5
15	23 50	7.944	21.42	43 59	17 39.2
15	25 17	7.796	22.88	45.05	17 35.8
15	27 10	7.873	22.12	44.29	17 40.2
15	29 33	7.748	23.36	45.53	17 38.1
15	30 50	7.630	24.53	46.70	17 35.9
15	33 27	7.599	24.83	47.00	17 36.5
15	37 0	7.482	25.99	48.16	17 35.3
15	39 15	7.390	26.90	49.07	17 33.6
15	41 20	7.443	26.38	48.55	17 38.0
15	42 52	7.339	27.41	49.58	17 34.8
15	44 33	7.304	27.76	49.93	17 34.8
15	46 20	7.300	27.80	49.97	17 36.4
15	47 27	7.245	28.34	50.51	17 35.0
15	49 5	7.235	28.44	50.61	17 36.0
15	50 15	7.285	27.94	50.11	17 39.7
15	16 53 20	7.178	29.00	51.17	17 37.2
			Mean		17 36.9

Mt. Hamilton, 1893 *September* 18.

NEW ASTEROIDS.

Prof. Krueger has transmitted the discovery of five small planets by Mr. Charlois.

						α	δ	Daily Motion
				h m		h m s	° ′ ″	
1893	*AI*	12M	Sept. 15	8 53.5	Nice M.T.	0 3 6.4	− 3 18 2	—56s in α. and 0′ in δ.
	AK	12M	18	10 32.0	"	0 19 12	+10 45	—44s in α, and 8′ southward.
	AL	11M	18	10 32.0	"	0 30 4	+16 28	—52s in α, and 1′ northward.
	AM	12M	18	10 32.0	"	0 37 28	+13 5	—52s in α, and 4′ southward.
	AN	11½M	20	13 22.0	"	1 20 48	+11 54	—48s in α. and 5′ southward.

The planet 1893 *S* proves to be that which was found by Prof. Wolf, 1891 Nov. 28, but to which no permanent number was then given.

The planet 1893 *AF* (Charlois, Aug. 9) proves to be no. 158, *Coronis*.

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OBSERVATIONS OF VARIABLE STARS OF THE *ALGOL*-TYPE, 1892–1893,

By PAUL S. YENDELL.

The present paper details the results of my observations upon the variables of this class, during the sixteen months from 1892 May 1 to 1893 September 1, and is a continuation of the series, of which the paper next preceding was published in this Journal, Vol. XII, p. 42.

The observations include all the known stars of this type, with the exception of *S Cancri*, of which no minimum has been observed, and *Y Cygni*, the observations of which are reserved for publication by themselves at the end of the season.

The methods of reduction used are the same as heretofore, except that in the case of *U Cephei*, a mean light-curve formed from all my own observations up to the date of this paper is used, and in that of *λ Tauri*, apparent variations of the light-curve render the results deduced from mean curves misleading in many cases, so that for this star, the use of this form of reduction has been discontinued.

320. *U Cephei.*

Seven minima.

1893 July 6; twenty-three observations, from $9^h 50^m$ to $14^h 33^m$.

Time of minimum by single curve, $12^h 34^m$, wt. 5.
" " mean curve, 12 38.5.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.6	11 18	14 4	12 46.0
8.8	11 23	13 58	12 40.5
9.0	11 26	13 52	12 39.0
9.2	11 33	13 38	12 35.5
Mean			12 40.25

Least observed light, $9^M.31$.

1893 July 16; sixteen observations, from $10^h 1^m$ to $14^h 0^m$.

Time of minimum by single curve, $11^h 40^m$, wt. 5.
" " mean curve, 11 53 .3.
" " equal light.

	Before	After	Mean
M	h m	h m	h m
8.6	10 12	13 34	11 53.0
8.8	10 21	13 27	11 54.0
9.0	10 32	13 20	11 56.0
9.2	10 42	13 4	11 53.0
9.4	10 57	12 36	11 46.5
Mean			11 52.5

Least observed light, $9^M.49$.

1893 July 21; twenty-three observations, from $8^h 25^m$ to $14^h 25^m$.

Time of minimum by single curve, $11^h 27^m.0$, wt. 5.
" " mean curve, 11 48 .8.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.6	10 1	13 19	11 40.0
8.8	10 10	13 16	11 43.0
9.0	10 20	13 10	11 45.0
9.2	10 28	12 50	11 39 0
9.4	10 38	12 28	11 33.0
Mean			11 40.0

Least observed light, $9^M.49$.

1893 August 5; fourteen observations, from $9^h 55^m$ to $12^h 56^m$.

Time of minimum by single curve, $10^h 42^m$, wt. 4.
" " mean curve, 10 43 .1.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
9.0	10 8	11 36	10 52.0
9.2	10 19	11 25	10 52.0
9.4	10 23	11 15	10 49.0
Mean			10 51.3

Least observed light, $9^M.52$.

1893 August 10; twenty-one observations, from $8^h 5^m$ to $12^h 18^m$.

Time of minimum by single curve, $10^h 12^m$, wt. 5.
" " mean curve, 10 11 .1.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.2	8 7	12 6	10 6.5
8.4	8 13	12 1	10 7.0
8.6	8 22	11 58	10 10.0
8.8	8 35	11 54	10 14.5
9.0	8 46	11 44	10 15.0
9.2	8 55	11 30	10 12.5
9.4	9 8	11 17	10 12.5
Mean			10 11.1

Least observed light, $9^M.52$.

1893 August 15; thirteen observations, from $8^h\ 4^m$ to $11^h\ 55^m$.

Time of minimum by single curve, $9^h\ 53^m$, w. 5.
" " mean curve, 9 52 .5.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.2	8 7	11 24	9 45.5
8.4	8 18	11 20	9 49.0
8.6	8 23	11 18	9 50.5
8.8	8 32	11 16	9 54.0
9.0	8 38	11 14	9 56.0
9.2	8 47	11 12	9 59.5
9.4	8 56	10 43	9 49 5
Mean			9 52.0

Least observed light, $9^M.49$.

1893 August 25; eighteen observations, from $7^h\ 43^m$ to $11^h\ 38^m$.

Time of minimum by single curve, $8^h\ 48^m$, wt. 3.
" " mean curve, 8 36.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.8	7 44	10 25	9 4.5
9.0	7 47	10 18	9 2.5
9.2	7 50	10 5	8 57.5
9.4	7 58	9 45	8 51.5
Mean			8 59.0

Least observed light, $9^M.49$.

1090. *Algol.*

Two minima.

1892 Nov. 23; fourteen observations, from $6^h\ 10^m$ to $10^h\ 15^m$.

Time of minimum by single curve, $9^h\ 24^m$. wt. 3.
" " mean curve, 9 47 .7.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
3.2	8 35	10 15	9 25.0
3.3	8 55	10 2	9 28.5
3.4	9 2	9 52	9 27.0
3.5	9 10	9 32	9 21.0
Mean			9 25.1

Least observed light, $3^M.6$.

1893 August 5; nineteen observations, from $10^h\ 50^m$ to $15^h\ 6^m$. Moonlight, and, after midnight, some fog.

Time of minimum by single curve, $13^h\ 36^m$, wt. 4.
" " mean curve, 13 31 .8.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
2.8	11 28	15 0	13 14.0
2.9	12 0	14 48	13 24.0
3.0	12 25	14 38	13 31.5
3.1	12 42	14 23	13 32.5
3.2	13 8	14 0	13 34.0
Mean			13 27.2

Least observed light, $3^M.27$

1411. *λ Tauri.*

Two minima.

1892 Dec. 29; seven observations, from $6^h\ 25^m$ to $9^h\ 35^m$.

Time of minimum by single curve, $7^h\ 21^m$, wt. 4t.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
4.1	6 22	7 52	7 7.0
4.2	6 42	7 45	7 13.5
4.3	6 52	7 38	7 15.0
Mean			7 11.8

Least observed light, $4^M.5$.

1893 March 6; eleven observations, from' $7^h\ 58^m$ to $10^h\ 20^m$.

Time of minimum by single curve, $10^h\ 3^m$, wt. 3.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
4.1	9 50	10 20	10 5
4.2	9 54	10 10	10 2
Mean			10 3.5

Least observed light, $4^M.3$.

2610. *R Canis Majoris.*

Two minima.

1893 Feb. 26; twelve observations, from $7^h\ 45^m$ to $11^h\ 0^m$.

Time of minimum by single curve, $10^h\ 4^m$, wt. 4.
" " mean curve, 9 57.5.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
6.5	9 32	10 43	10 7.5
6.7	9 48	10 17	10 2.5
Mean			10 5.0

Least observed light, $6^M.83$.

1893 March 6; eleven observations, from $8^h\ 0^m$ to $10^h\ 35^m$.

Time of minimum by single curve, $9^h\ 14^m$, wt. 4.
" " mean curve, 9 10.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
6.5	8 36	9 48	9 12.0
6.7	8 50	9 34	9 12.0
Mean			9 12

Least observed light, $6^M.8$.

3407. *S Antliae.*

Four minima.

1893 March 7; fourteen observations, from $8^h\ 42^m$ to $10^h\ 47^m$.

Time of minimum by single curve, $9^h\ 57^m$, wt. 5.
" " mean curve, 9 59.2.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
7.0	9 12.5	10 40	9 56.25
7.1	9 38.5	10 5	9 51.75
Mean			9 54.00

Least observed light, $7^M.17$.

1893 March 18; thirteen observations, from 8^h 35^m to 10^h 51^m.

Time of minimum by single curve, 10^h 6^m, wt. 5.
" " mean curve, 9 59.5.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
6.9	8 55.5	10 51.0	9 53.25
7.0	9 27.0	10 41.5	10 4.25
7.1	10 3.5	10 8.5	10 6.00
Mean			10 1.17

Least observed light, 7^M.12.

1893 March 21; eleven observations, from 7^h 36^m to 9^h 15^m.

Time of minimum by single curve, 8^h 15^m, wt. 5.
" " mean curve, 8 9.4.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
7.0	7 40.0	8 40.0	8 10.00
7.1	8 4.0	8 23.5	8 13.75
Mean			8 11.88

Least observed light, 7^M.12.

1893 April 11; eight observations, from 8^h 47^m to 10^h 30^m.

Time of minimum by single curve, 9^h 41^m, wt. 5.
" " mean curve, 9 42.3.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
7.0	9 7.0	10 26.0	9 46.50
7.1	9 27.0	9 48.0	9 37.50
Mean			9 42.00

Least observed light, 7^M.14.

1893 March 6; nine observations, from 8^h 30^m to 10^h 35^m; no minimum observed.

Time of minimum by mean curve, 10^h 30^m.0.

5374. *S Librae.*

One minimum.

1893 May 24; sixteen observations, from 8^h 45^m to 13^h 22^m; bright moonlight.

Time of minimum by single curve, 11^h 50^m, wt. 3.
" " mean curve, 12 0.6.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
5.3	9 2.5	13 3.0	11 2.75
5.5	10 9.0	12 49.0	11 29.00
5.7	10 47.0	12 42.0	11 44.50
Mean			11 25.40

Least observed light, 5^M.83.

5484. *U Coronae.*

Four minima.

1893 April 23; thirteen observations, from 8^h 0^m to 12^h 10^m.

Time of minimum by single curve, 11^h 24^m, wt. 3.
" " mean curve, 11 29.

Least observed light, 9^M.1.

1893 May 24; sixteen observations, from 8^h 30^m to 13^h 30^m.

Time of minimum by single curve, 12^h 56^m, wt. 3.
" " mean curve, 13 10.8.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.9	12 14	13 30	12 52

Least observed light, 9^M.05.

1893 July 1; eleven observations, from 9^h 59^m to 12^h 58^m.

Time of minimum by single curve, 11^h 55^m, wt. 1.
" " mean curve, 11 58.1.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
8.9	11 22	12 48	12 5

Least observed light, 9^M.1.

1893 August 8; thirteen observations, from 8^h 21^m to 12^h 35^m.

Time of minimum by single curve, 11^h 13^m, wt. 3.
" " mean curve, 11 37.5.

Least observed light, 9^M.1.

6189. *U Ophiuchi.*

Five minima.

1892 June 6; seven observations, from 9^h 0^m to 10^h 15^m.

Time of minimum by single curve, 9^h 42^m, wt. 2.
" " mean curve, 9 47.4.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
6.6	9 28	9 50	9 39

Least observed light, 6^M.63.

1893 June 10; ten observations, from 9^h 7^m to 12^h 7^m.

Time of minimum by single curve, 10^h 47^m, wt. 4.
" " mean curve, 10 42.5.
" " equal lights,

	Before	After	Mean
M	h m	h m	h m
6.5	9 48	12 2	10 55.0
6.6	10 11	11 22	10 46.5
Mean			10 50.75

Least observed light, 6^M.68.

1893 July 6; thirteen observations, from 9^h 15^m to 14^h 15^m.

Time of minimum by single curve, 10^h 31^m, wt. 4.
" " mean curve, 10 55.9.
" " equal light,

	Before	After	Mean
M	h m	h m	h m
6.5	9 28	11 42	10 35

Least observed light, 6^M.60.

1893 July 16 ; ten observations, from $9^h\ 48^m$ to $13^h\ 28^m$.

Time of minimum by single curve, $11^h\ 43^m$, wt. 5.

" " mean curve, 11 31.0.

" " equal light,

M	Before h m	After h m	Mean h m
6.5	9 58	12 56	11 27.0
6.6	11 3	12 7	11 35.0
Mean			11 31.0

Least observed light, $6^M.68$.

Dorchester, Mass., 1893 *September* 2.

1893 July 21 ; fourteen observations, from $8^h\ 40^m$ to $13^h\ 25^m$.

Time of minimum by single curve, $12^h\ 45^m$, wt. 4.

" " mean curve, 12 36.8.

" " equal light,

M	Before h m	After h m	Mean h m
6.6	12 15	13 20	12 47.5
6.7	12 24	12 48	12 36.0
Mean			12 41.8

Least observed light, $6^M.75$.

A SIMPLE GEOMETRICAL EXPLANATION OF THE CAUSE OF THE OBSERVED DISTORTIONS OF THE SHADOWS OF *JUPITER'S* SATELLITES,

BY J. M. SCHAEBERLE.

The hitherto puzzling phenomena attending the observations of the shadows of *Jupiter's* satellites have frequently been commented upon, but no satisfactory explanation has, to my knowledge, ever been presented.

The solution of the problem which I now give is of so simple a nature that all doubt as to its validity is removed, as the proof only involves purely geometrical principles.

Let R denote the radius of *Jupiter.*

Let r denote the radius of the satellite's shadow-cone where it intersects the surface of *Jupiter.*

For any given position of the shadow on the disk of *Jupiter* let $\frac{S'}{R}$ and $\frac{S''}{R}$ denote the distances from the center of the disk to the nearest and farthest points of the oval shadow then, as viewed from the sun, we always have

$$(1)\qquad \frac{S''}{R}-\frac{S'}{R}=\frac{2r}{R}$$

The longest diameter of the oval will be projected along a radius of the disk and its actual length d' measured on the surface of *Jupiter* will be

$$(2)\qquad d'=R\left(\sin^{-1}\left(\frac{S''}{R}\right)-\sin^{-1}\left(\frac{S'}{R}\right)\right)$$

The diameter d_0' at right angles to the radius will be constant and given by the equation

$$(3)\qquad d_0'=2R\sin^{-1}\left(\frac{r}{R}\right)$$

To avoid, for the present, more involved expressions, we will only treat of the case of a shadow moving along the equator of *Jupiter.* As both the earth and the sun are nearly in the plane of *Jupiter's* equator, we can, without appreciable error, substitute for the equatorial arc of the shadow its chord, as both have the same projection when the whole shadow arc is actually visible. The length d of this equatorial chord will be given by the expression

$$(4)\qquad d=2\ R\sin\tfrac{1}{2}\left(\sin^{-1}\left(\frac{S''}{R}\right)-\sin^{-1}\left(\frac{S'}{R}\right)\right)$$

The inclination i of this same chord to a line drawn to the sun is given by the equation

$$i=90^\circ-\tfrac{1}{2}\left(\sin^{-1}\left(\frac{S''}{R}\right)+\sin^{-1}\left(\frac{S'}{R}\right)\right)\qquad(5)$$

Now let θ denote the angular distance between the earth and sun as seen from *Jupiter*, the inclination of the chord to the actual line of sight will then be

$$\theta\pm i$$

Consequently the observed length l of the chord projected on a plane which is perpendicular to the line of sight will be

$$l=2R\sin\tfrac{1}{2}\left(\sin^{-1}\left(\frac{S''}{R}\right)-\sin^{-1}\left(\frac{S'}{R}\right)\right)\sin(\theta\pm i)\qquad(6)$$

The plus sign being used when the shadow is on that side of the center, which is toward the *visible* terminator, and the minus sign when the shadow is on the side of the *invisible* terminator.

Let us now consider some special cases of equation (6). When $\theta=0^\circ$ or 180°, equation (6) reduces to

$$i=\frac{2r}{R}\qquad(7)$$

for all values of i, as it evidently should. In other words, when the planet is in opposition (or conjunction) there will be no distortions of the shadow from a circular outline.

When $i=90^\circ$ equation (6) reduces to

$$l_0=R\,\frac{2r}{R}\cos\theta\qquad(8)$$

Now as θ can never much exceed 12°, it follows that when the shadow is on the central meridian the longitudinal diameter will never be less than 0.97 of the transverse diameter of the shadow.

The angle i can never equal zero, its minimum value i_m is for the position when the shadow is tangent to the terminator internally. For this case $S''=R$ and equation (5) becomes

$$i_m=\tfrac{1}{2}\ \mathrm{covers}^{-1}\left(\frac{2r}{R}\right)\qquad(9)$$

Substituting this value of i_m in equation (6) and using the positive sign, we obtain the *observed* value of l_m for the *visible* terminator. (10)

$$l_m = 2R \sin \tfrac{1}{2} \left[\text{covers}^{-1}\left(\frac{2r}{R}\right)\right] \sin \left[\theta + \tfrac{1}{2} \text{covers}^{-1}\left(\frac{2r}{R}\right)\right]$$

The value of l_m corresponding to a negative value of i_m can not be used when θ has a finite value, for the reason that near the invisible terminator only a portion (if any) of the actual shadow can be seen from the earth on account of the curvature of *Jupiter's* surface, so that the chord and arc no longer have the same projection.

To obtain the expression for the *observed* value of l when the shadow-cone is tangent internally to the full outline (near the invisible terminator) of the planet we must place $\frac{S''}{R} = \cos\theta$ and $\frac{S'}{R} = 1 - \left(\text{cover } \theta + \frac{2r}{R}\right)$. The expression for the actual length of the chord as given by equation (4) then becomes

$$(11) \qquad d = 2R \sin \tfrac{1}{2}\left(\theta - \text{covers}^{-1}\left(\text{covers } \theta + \frac{2r}{R}\right)\right)$$

This inclination of this chord to a line drawn to the sun is

$$(12) \qquad i = \tfrac{1}{2}\left(\theta + \text{covers}^{-1}\left(\text{covers } \theta + \frac{2r}{R}\right)\right)$$

And the inclination of the chord to the actual line of sight will be $\theta - i$. Consequently the *observed* length l will be

$$(13) \qquad l = d \sin(\theta - i)$$

Let us now take the shadow of *Jupiter's* first satellite as an example illustrating the application of the formulas. We know from observation that very slight variations of surface shadings in a satellite may produce very marked contrasts when projected against the disk of *Jupiter*. From this fact it is probable that both the umbra, and more or less of the penumbra, are involved in the observed measure of a shadow.

However, for illustration, let us take the diameter of the shadow at 2000 miles, and the equatorial diameter of *Jupiter* at 88200 miles, and determine the phenomena for a maximum value of $\theta = 12°$, or for the time when *Jupiter* is in quadrature.

Lick Observatory, 1893 *September* 5.

At the center of the planet the two observed diameters of the shadow will be, according to equation (8),

Longitudinal,	1950 miles
Transverse,	2000 "

When the shadow is just tangent to the *visible* terminator the *observed* dimensions are, according to equation (10),

Longitudinal,	5400 miles
Transverse,	2000 "

That is, the *observed* length is more than twice the breadth of the shadow.

When the shadow is just tangent internally to the full outline (near the invisible terminator) of the planet, the observed dimensions of the shadow, according to equation (13), are

Longitudinal,	550 miles
Transverse.	2000 "

Or the *observed* length measured along the equator is but little more than one-fourth of the breadth in latitude.

The interpretation of equation (6) therefore, enables us to enunciate the following almost self-evident law for central transits.

The shadow of a satellite of a superior planet as seen from the earth will, for θ greater than zero, always be elongated in the direction of the equator near the visible terminator, and contracted in the same direction near the invisible terminator. The distortion is practically zero near the center of the disk, and has maximum values when the shadow is internally tangent to the visible outlines of the disk. When the planet is in opposition (or conjunction), there are no appreciable geometrical distortions.

It is evident that when the transit of the shadow is not central, the same general conditions will prevail, only the distortions will then be oblique to the equator.

NOTE. When the shadow falls centrally upon a narrow bright belt or spot on *Jupiter* an apparent contraction of the penumbral portion of the shadow will cause an apparent double shadow, especially when the seeing is not first-class.

Near the visible terminator the two components will always lie along a radius, but near the invisible terminator they will lie on a line parallel to the circumference. The components will always be largest near the visible terminator, and smallest near the invisible terminator.

J. M. S.

ROBERTS'S VARIABLE IN *CARINA*.

BY EDWARD C. PICKERING.

In the *Astronomical Journal*, Vol., XIII, p. 110, Dr. CHANDLER discusses the variability, discovered by Mr. A. W. ROBERTS, of the star whose position for 1875 is in R.A. $8^h\ 28^m\ 34^s$, Decl. $-58°\ 48'\ 10''$. After failing to identify the object he states that "The singular confirmation by the H.C.O. photographs of the variation of a star apparently not the variable, is thus unaccounted for." This "singular confirmation" is now explained by a letter just received from Mr. ROBERTS. In it he states, first, that this star was correctly identified by Mrs. FLEMING as Z.C. VIII, 2388 (*Astr. Jour.* Vol. XIII, p. 79) and is that whose variability he observed; and secondly, that although he had already announced the variability of Lacaille 3393 (*British Astronomical Journal*, II, 334), as the two stars are a degree apart, he did not anticipate that they would be supposed to be the same object. Of course the evidence of variability afforded by the Harvard photographs may be examined at any time by those interested in the matter. A constant difference between the photographic and the visual magnitudes is readily accounted for by a difference in color in the stars compared.

Harvard College Observatory, 1893 *September* 30.

FILAR-MICROMETER OBSERVATIONS OF COMET *b* 1893,

MADE WITH THE 7½-INCH TELESCOPE OF THE OBSERVATORY OF THE STATE UNIVERSITY OF MISSOURI,

BY MILTON UPDEGRAFF.

1893 Columbia M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
h m s			m s	' "	h m s	° ' "		
July 11 9 45 12	1	3	+4 9.67	+0 8.2	9 7 1.80	+44 56 30.9	9.751	0.803
12 9 36 49	2	5	+1 46.86	+0 8.8	9 34 28.97	+42 46 24.5	9.764	0.764
13 9 5 59	3	7	—3 22.63	—0 4.7	9 57 15.6	+40 28.3	9.775	0.694
14 9 15 41	4	7	+4 46.72	+2 29.7	10 16 52.55	+35 5 12.5	9.762	0.692
16 9 8 10	5	8	—0 19.14	+4 26.5	10 46 25.63	+33 38 2.8	9.742	0.668
17 9 26 56	6	4	—2 5.02	—4 31.2	10 57 52.0	+31 35.6	9.731	0.693
19 9 5 35	7	10	—0 10.13	+0 9.4	11 15 19.56	+28 4 44.9	9.715	0.666
20 9 19 32	8	7	—1 28.00	+3 32 1	11 22 18.92	+26 31 23.3	9.711	0.687
22 8 44 50	9	9	+0 6.96	—3 13.7	11 33 16.34	+23 52 7.1	9.693	0.655
23 9 0 49	10	8	+1 16.93	—7 12.7	11 37 50.00	+22 41 14.6	9.694	0.677
24 8 48 9	11	6	+4 26.11	—2 56.9	11 41 43.74	+21 37 38.9	9.686	0.671
27 8 53 42	12	8	—0 55.41	—3 41.2	11 51 1 31	+18 55 44.4	9.682	0.691
Aug. 3 8 50 24	13	6	—2 29.08	—3 53.7	12 4 0.94	+14 32 53.2	9.674	0.715
4 8 54 50	14	5	+5 35.62	+0 9.4	12 5 17.76	+14 4 17.0	9.675	0.721
5 8 41 38	15	7	—0 3.01	+2 1.5	12 6 27.94	+13 37 43.6	9.672	0.716
7 8 23 30	16	8	—0 2.58	+3 56.9	12 8 35.09	+12 48 28.6	9.667	0.711
9 8 27 22	17	4	+2 40.10	—2 45.5	12 10 27.47	+12 3 42.2	9.669	0.719
11 8 27 47	18	6	+1 51.72	—4 15.2	12 12 7.58	+11 23 26.9	9.669	0.724

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ' "	"	
1	9 2 51.83	+0.30	+44 56 14.5	+8.2	W.B. VIII, 1486
2	9 32 41.68	+0.43	+42 46 7.8	+7.9	W.B. IX, 640
3	10 0 37.6	+0.55	+40 28.3	+7.4	DM. 40°2289
4	10 12 5.24	+0.59	+38 2 35.9	+6.9	W.B. X, 197
5	10 46 44.06	+0.71	+33 33 30.7	+5.6	W.B. X, 902
6	10 59 56.2	+0.75	+31 40.0	+5.0	DM. 31°2232
7	11 15 28.92	+0.77	+28 4 31.5	+4.0	W.B. XI, 241
8	11 23 46.14	+0.78	+26 27 47.8	+3.4	W.B. XI, 403
9	11 33 8.50	+0.78	+23 55 18.2	+2.6	W.B. XI, 600
10	11 36 32.28	+0.79	+22 48 25.1	+2.2	W.B. XI, 679
11	11 37 16.85	+0.78	+21 40 33.9	+1.9	W.B. XI, 694
12	11 51 55.90	+0.82	+18 58 24.9	+0.7	W.B. XI, 975
13	12 6 29.24	+0.78	+14 36 47.5	—0.6	W.B. XII, 92
14	11 59 41.40	+0.74	+14 4 8.2	—0.6	½(Schjellerup+Paris)
15	12 6 30.19	+0.76	+13 35 43.1	—1.0	Schjellerup 4403
16	12 8 36.91	+0.76	+12 44 33.0	—1.3	Schjellerup 4415
17	12 7 46.62	+0.75	+12 6 29.2	—1.5	Lalande 22910
18	12 10 15.11	+0.75	+11 27 43.9	—1.8	Schjellerup 4428

The observations of July 11 and 17, and of August 9 and 11 are rather poor. When appreciable, the corrections for differential refraction have been computed and applied.

EPHEMERIS OF COMET 1892 III (*HOLMES*),

BY CHARLES S. BENTON.

(Continued from No. 299.)

Gr. M.T.	App. α h m s	App. δ ° ′ ″	log Δ
'93 Oct. 21.5	8 32 50.2	+34 58 6	0.56196
23.5	8 33 55.1	34 58 45	0.55929
25.5	8 34 55.6	34 59 39	0.55660
27.5	8 35 51.2	35 0 49	0.55389
29.5	8 36 42.7	35 2 16	0.55116
31.5	8 37 29.1	35 4 0	0.54842
Nov. 2.5	8 38 10.7	35 6 1	0.54567
4.5	8 38 47.2	35 8 19	0.54290
6.5	8 39 18.8	35 10 52	0.54015
8.5	8 39 45.3	35 13 42	0.53740
10.5	8 40 6.6	35 16 47	0.53165
12.5	8 40 22.6	35 20 8	0.53192
14.5	8 40 33.2	35 23 43	0.52921
16.5	8 40 38.4	35 27 33	0.52652
18.5	8 40 38.1	35 31 36	0.52386
20.5	8 40 32.3	35 35 52	0.52124
22.5	8 40 21.0	35 40 20	0.51866
24.5	8 40 4.0	35 45 0	0.51612
26.5	8 39 41.5	+35 49 48	0.51361
Nov. 28.5	8 39 13.3	+35 54 47	0.51122
30.5	8 38 39.3	35 59 52	0.50886
Dec. 2.5	8 37 59.7	36 5 4	0.50658
4.5	8 37 14.4	36 10 20	0.50438
6.5	8 36 23.5	36 15 42	0.50226
8.5	8 35 27.0	36 21 3	0.50024
10.5	8 34 25.2	36 26 24	0.49832
12.5	8 33 18.0	36 31 43	0.49651
14.5	8 32 5.1	36 36 59	0.49481
16.5	8 30 48.2	36 42 8	0.49323
18.5	8 29 26.0	36 47 9	0.49178
20.5	8 27 59.1	36 51 59	0.49047
22.5	8 26 27.8	36 56 68	0.48929
24.5	8 24 52.4	37 1 3	0.48825
26.5	8 23 13.0	37 5 13	0.48737
28.5	8 21 30.0	37 9 4	0.48661
30.5	8 19 43.6	37 12 38	0.48606
'94 Jan. 1.5	8 17 54.1	+37 15 46	0.48566

OBSERVATIONS OF COMETS,

MADE WITH THE 16-INCH EQUATORIAL AND FILAR MICROMETER OF GOODSELL OBSERVATORY, NORTHFIELD, MINN.,

BY H. C. WILSON.

[Communicated by WM. W. PAYNE, Director.]

1893 Northfield M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
COMET 1892 VI (BROOKS, AUG. 28).								
June 12 13h 50m 16s	1	6 , 2	+6m 9s.12	+1′ 14″.7	17h 32m 39s.39	—24° 13′ 16″.6	9.304	0.901
COMET *b* 1893.								
Aug. 3 8 32 56	2	6 , 4	—2 29.79	—3 34.9	12 4 0.23	+14 34 12.0	9.633	0.756
7 8 51 52	3	12 , 6	—0 1.23	+3 33.1	12 8 36.45	+12 48 4.8	9.635	0.775
COMET *a* 1893 (FINLAY).								
Aug. 16 15 37 14	4	6 , 4	+2 0.36	—5 11.4	6 21 4.16	+23 18 3.9	*n*9.647	0 700

Mean Places for 1893.0 of Comparison-Stars.

*	α h m s	Red. to app. place s	δ ° ′ ″	Red. to app. place ″	Authority
1	17 26 27.73	+2.51	—24 14 21.7	—9.6	Oe. Arg. S. 13438
2	12 6 29.24	+0.78	+14 37 47.5	—0.6	Weisse's Bessel XII, 92
3	12 8 36.92	+0.76	+12 41 33.0	—1.3	Schjellerup 4415
4	6 19 2.83	+0.97	+23 23 7.1	+8.2	Brussels 2624

Comet 1892 VI was seen again July 18, but was too faint and diffuse for measurement.

Comet *b* 1893 was seen, and could easily have been observed on Aug. 17 and 18 had there been any good comparison-star near.

FINLAY's comet, Aug. 16, was faint, about 1′ in diameter, slightly condensed in the center. It was looked for again on Sept. 14, but was not found.

Careful search was made with the 16-inch for HOLMES's comet (*f* 1892) Aug. 16 and Sept. 14, but no trace of it was seen.

THE APPARENT BRIGHTNESS OF COMET *b* 1893,

BY EDWIN F. SAWYER.

In connection with my variable-star and photometric work, I took occasion to obtain a few observations for brightness of the late conspicuous comet. These observations were made with an opera-glass magnifying 2½ diameters; the same being placed slightly out of focus, as is customary in making my observations and more particularly in the present case, to allow a better comparison between the disk of light presented by the comet's nucleus and coma, and the points of light presented by the stars. Two or more stars for comparison were used at each observation. The deduced magnitude of the comet for each evening is found by taking the mean magnitude of the stars as given in the following catalogues and reducing the same to ARGELANDER's scale;— DM., HEIS, U.N., PRICHARD, Harvard Photometric.

The observations were made under rather poor conditions, owing to the comet's near approach to the sunset horizon and from the advancing moonlight. The determined magnitudes appear somewhat brighter than those fixed by Professor Boss (*A.J.* No. 301). The comet apparently brightened slightly, somewhere between July 19 and 20.

OBSERVATIONS.

	d	h	m	Magnitude	Remarks
1893 July	13	9	0	3.30	Tail 2½°
	14	9	30	3.50	Tail 2°
	16	9	10	3.67	Tail fainter 1¾°
	19	9	0	4.56	Slight traces of tail
	20	9	30	4.48	Comet appar. brighter
	23	8	50	4.73	Moon
	24	9	15	5.10	Moon
	30	8	45	5.76	
Aug.	3	9	0	5.93	Low

Brighton, 1893 *October* 16.

COMET *c* 1893.

A bright comet with short tail was discovered by BROOKS, Oct. 16, in the position,

Oct. 16.875 Greenw. M.T., $\alpha = 12^h\ 21^m$, $\delta = +12°\ 55'$. Motion northeasterly, slow.

It was observed by Rev. GEORGE M. SEARLE at the Catholic University in Washington,

Oct. 17 $22^h\ 11^m\ 18^s$ Greenw. M.T. App. $\alpha = 12^h\ 23^m\ 1^s.4$, App. $\delta = +13°\ 34'\ 36''$.

Father SEARLE describes it as quite bright, its total effect being about 7^M, with a tail perhaps 2° long.

No other observation has yet been received.

1893 *October* 22.

ASTRONOMICAL JOURNAL PRIZE.

The judges for the award of the *Astronomical Journal* prizes, after careful consideration, desire to suggest that the period specified in the offer of the prize for observations of comets (No. I, on p. 160, *A.J.*, Vol. XII), be extended by six months, to September 30, 1894. The reasons therefor are as follows.

During the past six months but one comet has been discovered, and the period of its visibility was unusually short. Meanwhile winter is approaching, during which the usually prevailing climatic conditions are likely to reduce chances for observation, even if the supply of new comets should not be restricted, as is also usual, for the same reason. It is therefore probable that, from causes beyond the control of the observers, there will be inadequate opportunity for worthy competition for so generous a prize.

To meet this unforeseen state of things by a measure in the interests of the candidates for the award, and fair to all of them alike, the above extension of time is proposed. The judges therefore desire courteously to recommend that, if the suggestion meets the approval of the donor, the terms of the offer should be modified in accordance therewith.

ASAPH HALL.
S. C. CHANDLER.
LEWIS BOSS.

1893 *October* 7.

The Editor of the *Astronomical Journal* has received from the donor of the prizes full authority to assent to this proposition; and the period comprised in the offer is therefore extended by six months, closing 1894 September 30.

CORRIGENDA.

No. 303, p. 130, col. 2, line 18, *for* 32.6 *put* 31.4; line 39, *for* 31.86 *put* 31.38.

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PRELIMINARY NOTE ON A MECHANICAL THEORY OF COMETS,

BY J. M. SCHAEBERLE.

In my paper on "A Mechanical Theory of Comets," written three years ago, the concluding paragraph begins as follows:

"The hypothesis, favored by some astronomers, that the matter now revolving about the sun in cometary orbits was once ejected from the sun is, according to the Mechanical Theory rendered extremely probable, and it would not be difficult to bring forward many strong arguments to support this view, and to account for many apparent changes of form in cometary matter."

Lately, various data (especially those given by my large coronal photographs of the last eclipse) have become available, the character of which is such that no apology is needed for presenting my views on the nature of comets at this time, especially as this new theory of comets is a strictly logical consequence of the mechanical theory of the corona.

Direct observations of the sun's immediate surroundings demonstrate the presence of masses of matter ejected from the sun with very great velocity. That this matter is not of a uniform density seems to be plainly proved by the evidence of the eclipse photographs. The prominences, for instance, rise to certain limiting heights, corresponding to certain definite initial velocities of motion. The coronal streams, on the other hand, rise to indefinite heights, and must therefore have, in general, much greater initial velocities.

Any given eruption doubtless gives rise to both prominences and streams. As the ejective force may be assumed common to both, the mass of a given volume of a coronal stream must be less than that of a prominence, and this evidence is given by all eclipse-photographs showing both forms.

Now let v denote the velocity of a portion of a prominence whose mass to a given volume is m, and let v' denote the velocity of a portion of a coronal stream whose mass for the same volume is m', then for the same ejective force F we shall have, if atmospheric resistances are zero,

$$F = m\,v^2 = m'\,v'^2$$

or,

$$v' = v\sqrt{\frac{m}{m'}}$$

The individual particles going to make up the mass m, for example, will not necessarily have equal masses; but, on account of their proximity to each other, all are constrained to have a common velocity v. Similarly all the particles in the mass m' are forced to move with the common velocity v'.

If now we assume the mean density of a coronal stream to be even as great as one-seventh of that of an accompanying prominence, the same explosive force which during the last eclipse sent prominence matter to a height of 80 000 miles, will send coronal matter forming the streams to an infinite distance.

Each eruption, then, is sending out minute particles of matter with great velocity, and the solid angle of the conical surface inclosing them all may evidently be quite large. Aside from gravitational influences these particles suffer no resistance to motion in space, except where they come into contact with other particles of matter moving in vacuo.

If each particle moves along a normal to the sun's surface the density at any given point of a stream will vary inversely as the square of the distance from the sun's center, and inversely as the velocity; but, as the velocity varies inversely as the square root of the distance, the density must vary inversely as the cube of the square root of the distance from the sun's center.

In the following table the velocities and corresponding densities of a stream have been computed for various distances from the sun, assuming an initial parabolic velocity. The density near the sun's surface is placed equal to unity. The unit of distance is the earth's mean distance from the sun.

Distance	Velocity in miles per sec.	Density	Distance	Velocity in miles per sec.	Density
0.005	370	0.936	0.10	82.7	0.0100
.006	338	.712	.20	58.5	.0037
.007	313	.565	.30	47.8	.0020
.008	292	.462	.40	41.4	.0013
.009	276	.387	.50	37.0	.0009
			.60	33.8	.0007
.01	262	.331	.70	31.3	.0006
.02	185	.117	.80	29.2	.0005
.03	151	.064	.90	27.6	.0004
.04	131	.041			
.05	117	.030	1.0	26.2	.00030
.06	107	.023	2.0	18.5	.00012
.07	99	.018	3.0	15.1	.00006
.08	92	.015	4.0	13.1	.00004
.09	87	.012	5.0	11.7	.00003
0.10	83	0.010	6.0	10.7	0.00002

The above densities refer to streams having a parabolic velocity for which the density becomes zero when the distance is infinite. I find, however, that for a certain limiting elliptical velocity (limiting only because of the sun's rotation) the density at first decreases with the distance, then a gradual increase takes place until the densest portion of the whole stream is at the point where the velocity is least. Additional evidence, that the coronal matter visible during the last eclipse was in rapid motion, is to be found in the observed fact that the curved returning coronal streams shown on my large photographs are apparently most dense in the higher regions. The same is true of the distribution of the prominence matter.

With the foregoing principles as a basis, I now come to a new theory of comets which has for its foundation only the simple action of purely mechanical forces, and entirely independent of those occult forces — electricity and magnetism.

As I shall treat the subject from a purely theoretical standpoint, all the statements and deductions here given refer to a theoretical comet produced by the theoretical causes named.

1. A comet (theoretical) is a large meteor whose composition is of such a nature that certain (or all) of its constituents are evaporated at comparatively low temperatures. The atmosphere thus formed will, on account of the small mass, always be most dense on the side where the evaporation is most rapid. When the evaporation ceases, this atmosphere will tend to arrange itself symmetrically with reference to the nucleus so long as no other material bodies come into contact with it. Tidal effects will always have a tendency to cause greater or less dissymmetry of form.

2. An increase of temperature brought about both by a diminishing distance from the sun and by collisions with minute material particles in space will be accompanied by a corresponding increase in the mass of the surrounding atmosphere due both to a more rapid evaporation from the nucleus, and to a temporary or permanent capture of the colliding particles.

3. The attraction which the nucleus exerts upon its atmosphere is so extremely small that each of the more distant particles of this atmosphere can be considered as describing an independent orbit, the mean of the separate orbits thus described practically coinciding with that of the nucleus. When the meteorite is very near the sun the evaporation on the sun side of the nucleus will be very rapid, which combined with tidal influences may result in the rupture of the nucleus.

4. The tail of a comet (theoretical) is produced both by the visible particles of matter originally forming the comet's atmosphere, and by the previously invisible particles of a coronal stream which moving with great velocity finally produce by repeated impact of the successive particles almost the same motions in the visible atmosphere of the comet as would be communicated by a continuously accelerating force directed away from the sun. The actions on the particles of the stream result in a diminution of the velocity of the more advanced portions which now become visible through a consequent increase of density. A peculiarity of this mechanical accelerating force is that it becomes zero when the particle repeatedly struck by a succession of other particles finally attains the same finite velocity as the stream of striking bodies.

5. As all the particles of a given coronal stream have the same velocity, the momentum of the heavier sets of particles will be greater than the momentum of those having less mass. Let $m_1, m_2, m_3 \ldots . m_n$ denote the masses of different particles of the stream which strike the comet's atmosphere; the total momentum at a given instant will be

$$v^2 \Sigma m = v^2 \Sigma m_1 + v^2 \Sigma m_2 + \ldots . v^2 \Sigma m_n$$

A particle whose mass is m_1 will penetrate the atmosphere to a distance s_1 before being brought to a state of rest relatively to the nucleus. Similarly the particles whose masses are $m_2, m_3 \ldots . m_n$ will penetrate the atmosphere to the respective distances $s_2, s_3 \ldots .. s_n$. The resulting strata of increased density of the comet's atmosphere will evidently be nearly concentric, the distances between any two strata f and t being $(s_f - s_t)$.

These strata of increased density will in projection be made manifest in the form of luminous, nearly concentric, arcs whose greatest brilliancy will, in general, be near the most advanced part of each stratum, and gradually diminish in brightness as they curve away to form the comet's tail.

6. The coronal matter, owing to its retardation, grows so dense that it also becomes visible, and with the comet's atmosphere is finally driven into the tail by the repeated bombardment of unretarded following portions of the stream.

It is evident that the resulting velocity of different parts of the comet's tail will depend both upon the mass of each individual striking particle, and upon the mass of the particle struck. In general, the coronal particles which have the greatest mass will after collision give the greatest velocity, which (like the remaining masses) is gradually accelerated as above described until the speed again becomes so great that no sensible illumination results from the scattered particles. The nucleus and inner portions of the atmosphere, being the most dense, block the passage of the particles so that the axis of the tail will usually have less matter than the space at some distance from the axis.

To keep this note within proper bounds, further general considerations must be published in another form. A simple inspection of the figures given in the preceding table will at once show how greatly the factor depending upon the distance from the sun influences the form of a comet in general.

The severest test of any given theory is its ability to account for abnormal deviations from a typical form. Some of the most remarkable will be briefly considered.

Many coronal streams issue from the sun at considerable angles with the normals; in space, therefore, different streams will cross each other without sensibly interfering with each other's motions. The atmosphere of a comet, however, when placed at such a crossing, will evidently produce as many different tails to the nucleus as there are crossing streams: the angles between the tails being a function of the velocities of motion and the inclinations of the streams.

There are several cases on record of comets having a tail turned *toward* the sun in addition to the usual appendage. I have examined every case known to me, and find that invariably at the time this phenomenon was observed the comet was *receding* from the sun with great velocity. *A coronal stream, having a less velocity than that of the receding comet, will under these circumstances cause just such a phenomenon the moment the comet enters the stream.* Evidently the main tail will in no way be sensibly affected, since the tenuity of the two coronal streams (one moving with greater velocity than the comet, and the other with less velocity) is so great that no sensible interdisturbance takes place.

Owing to the orbital motion of the comet different tails will result when the velocities in the tail (as a whole) at a given distance from the nucleus are largely and abruptly different. The curvature will be greatest for the tail which has the least velocity. If a gradual variation in the velocity results, a gradually broadening tail (in general more curved in projection on one side than on the other) will result.

Rapid variations in the form and brightness of the comet will result from the lateral orbital motion of the comet with respect to the stream, often passing from one stream into another. A comet loses its tail if for a considerable time it passes from a stream of greater (or less) velocity, into space sensibly devoid of coronal matter, or into a stream having the same velocity and direction of motion.

When the velocity of the particles in the more distant portions of the tail is much less than that of the streams the deviation of the axis of the tail from the produced radius vector of the nucleus will become so great that fresh and unretarded streams can plough their way through (across) these more distant parts of the tail, which may result in a visible phenomenon of a striated or columnar structure (as actually observed by Bond and others, in Donati's comet); the axis of each column being roughly parallel to the direction of these coronal streams.

Sudden and sharply abrupt changes in the direction of a comet's tail at great distances from the nucleus will be caused whenever the tail enters another coronal stream whose direction of motion is considerably inclined to the stream passing through the comet's nucleus.

A natural consequence of such motions of coronal matter is to deprive all bodies, of very small mass, of any non-growing atmosphere they may have; and also to fix the limit of distance beyond which a body of great mass cannot retain its atmosphere. In this connection I would again call attention to the fact that the phenomenon of the "Gegenschein" can be quite satisfactorily explained on this hypothesis, and that the results following from the capture of coronal particles by our own atmosphere leads to a plausible explanation of the aurora. [See Dec. 1889 Eclipse Report, Lick Observatory.]

This paper, as indicated by the title, is but a preliminary note on a theory which will be more completely discussed in the forthcoming "Report on the Eclipse of Apr. 16, 1893."

Lick Observatory, 1893 *October* 14.

A NEW METHOD OF FINDING THE PLACE OF A SHIP AT SEA.*

By JOHN N. STOCKWELL.

1. The place of a ship at sea may very easily be found by means of the altitudes or zenith distances of a pair of stars, at a given Greenwich time. In order to show this, we shall consider the spherical triangles whose vertices are at the north pole of the heavens, and at the two stars; and also at the zenith and stars. It is evident that the part of the great circle included between the two stars is the third side of the two triangles already mentioned. If, then, by means of the almanac places of the two stars, we compute the two angles and third side, which side will be the great circle distance between the pair of stars; we may then compute the spherical triangle, two of whose sides are the measured zenith distances, and the third side of which is the computed distance between the stars. We may then form two other spherical triangles whose vertices are at the north *pole* of the heavens, at the *zenith*, and at the two stars. Each of these triangles will have two sides, and the included angle known; and the third side will be common to both triangles, and be equal to the complement of the ship's latitude. The angles at the pole will then be the longitude of the ship measured from the meridians passing through the two stars; the positions of which can be found by means of the Greenwich time of the observations.

2. We shall now designate by $\alpha, \delta, \alpha' \delta'$; the right-ascension and declination of the two stars, and by c the distance between them. The angles which the side c makes

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* See Bode's *Jahrbuch* 1812: Gauss pp. 129–143, Calkoen p. 175. — *Jahrbuch* 1887: p. 135. Zach's *Monatl. Corr.*: XIX, Gauss, pp. 134–140; XXI, Delambre, p. 435. — Chauvenet I. pp. 258–262. — G.

with the declination circles passing through the stars being denoted by A and B; we may determine A, B and c, by the formulas,

$$\left\{\begin{aligned} \sin c \sin A &= \cos\delta \sin(\alpha'-\alpha) \\ \sin c \cos A &= \sin\delta \cos\delta' - \cos\delta \sin\delta' \cos(\alpha'-\alpha) \end{aligned}\right. \tag{1}$$

$$\left\{\begin{aligned} \sin c \sin B &= \cos\delta' \sin(\alpha'-\alpha) \\ \sin c \cos B &= \cos\delta \sin\delta' - \sin\delta \cos\delta' \cos(\alpha'-\alpha) \end{aligned}\right. \tag{2}$$

$$\cos c = \sin\delta \sin\delta' + \cos\delta \cos\delta' \cos(\alpha'-\alpha) \tag{3}$$

Equations (1) and (2) determine A, B and $\sin c$; but since the same sine corresponds to an angle, and also to its supplement, the value of c thus determined becomes ambiguous; the ambiguity can, however, be avoided by using equation (3) for the determination of c. We may now regard A, B, and c as known quantities.

Now if z denotes the zenith-distance of the star α, δ; and z' that of α' δ'; and A', B', denote the angles which the side c makes with the vertical circles passing through the two stars; we may find A' and B' by means of the equations:

$$\cos(\pm A') = \frac{\cos z - \cos z' \cos c}{\sin z' \sin c} \tag{4}$$

$$\cos(\pm B') = \frac{\cos z' - \cos z \cos c}{\sin z \sin c} \tag{5}$$

The upper signs in these equations are to be used when the pole and zenith are on the same side of the great circle passing through the stars; and the lower signs when they are on opposite sides of that circle.

If we now denote the longitude and latitude of the observer by λ and ϕ; and the longitudes of the meridians passing through the stars, by h and h', we shall have these four equations for the determination of λ and ϕ:

$$\sin\phi = \cos z \sin\delta + \sin z \cos\delta \cos(B'-B) \tag{6}$$

$$\sin\phi = \cos z' \sin\delta' + \sin z' \cos\delta' \cos(A-A') \tag{7}$$

$$\sin(\lambda-h) = \sin z \sec\phi \sin(B'-B) \tag{8}$$

$$\sin(\lambda-h') = \sin z' \sec\phi \sin(A-A') \tag{9}$$

We shall also have the following equation of condition which the values of h and h', derived from equations (8) and (9) must satisfy if the computations have been correctly made

$$h-h' = \alpha'-\alpha \tag{10}$$

3. The whole theory of this method of finding a ship's place at sea is contained in the ten equations of the preceding article. We see there are two solutions of the problem corresponding to the same zenith-distances of the two stars; but the correct solution can generally be determined by the observers noting whether the pole and zenith are on the same side, or on opposite sides of the great circle passing through the stars. If the zenith is in that great circle, we shall evidently have

$$z \pm z' = c$$

the upper sign taking place when the zenith is between the two stars. In this case we shall evidently have

$$A' = 0, \text{ and } B' = 0$$

In the other case, or when $c = z - z'$ if z' is less than z we shall have $A' = 180°$ and $B' = 0°$ but if z' is greater than z we shall have $A' = 0$ and $B' = 180°$. In all of these various cases, however, there is only one solution.

4. It is evident that the same method may be used for finding the place of an observer on land as well as at sea; and we shall illustrate it by the computation of an example from observations of the simultaneous zenith-distances of the stars *Arcturus* and *Antares*, made at this place on the evening of Sept. 14, 1893. At the assumed Greenwich time Sept. 14, $12^h\ 26^m\ 37^s.5$, the apparent zenith-distances, when corrected for refraction, were found to be

$$z = 59°\ 40'\ 32''.22, \qquad z' = 74°\ 27'\ 7''.07.$$

At the same time the apparent places of the stars were

$$\begin{array}{llll} \textit{Arcturus} & \alpha = \overset{\circ}{212}\ \overset{\prime}{41}\ \overset{\prime\prime}{54.6}, & & \delta = +\overset{\circ}{19}\ \overset{\prime}{44}\ \overset{\prime\prime}{17.9}, \\ \textit{Antares} & \alpha' = 245\ 43\ \ 6.6, & & \delta' = -26\ 11\ 53.0. \end{array}$$

Equations (1), (2) and (3) will now give

$$A = 38°\ 12'\ 53''.42, \qquad B = 143°\ 51'\ 48''.20,$$
$$c = 56°\ 0'\ 36''.80.$$

With this value of c and the above values of z and z', equations (4) and (5) will give

$$A' = \pm 63°\ 36'\ 36''.80, \qquad B' = \pm 91°\ 8'\ 16''.43.$$

But since the zenith and pole were on the same side of the great circle c, we must use the upper signs of A' and B', and we shall find

$$A-A' = -25°\ 23'\ 43''.38, \qquad B'-B = -53°\ 43'\ 31''.77.$$

Then equation (6) gives

$$\sin\phi = +0.7809079 - 0.1183358 = +0.6625721;$$

and equation (7) gives

$$\sin\phi = +0.4920565 + 0.1705156 = +0.6625721.$$

Therefore $\phi = +41°\ 29'\ 46''.7$.

Using this value of ϕ, equations (8) and (9) will give

$$\lambda-h = -66°\ 29'\ 55''.5; \qquad \lambda-h' = -33°\ 28'\ 43''.7.$$

Therefore $h-h' = 33°\ 1'\ 12''.0 = \alpha'-\alpha$.

Now the assumed Greenwich time of observation, $12^h\ 26^m\ 37^s.5$, corresponds to a sidereal interval of $12^h\ 28^m\ 40^s.15$, to which add the sidereal time of noon Sept. 14, $11^h\ 34^m\ 44^s.70$. The sum is $24^h\ 3^m\ 24^s.85 = 360°\ 51'$

12″.75. From this subtract the right-ascension of the stars, and we have

$$h = 148° \; 9' \; 18''.15, \qquad h' = 115° \; 8' \; 6''.15.$$

Therefore we obtain for the longitude and latitude of the place of observation

$$\lambda = 81° \; 39' \; 22''.65 = 5^h \; 26^m \; 37^s.5 \text{ ; and } \phi = +41° \; 29' \; 46''.7.$$

5. If we now use the lower signs in the values of A' and B', we shall find the coordinates of the second place of observation. They give

$$A - A' = 101° \; 49' \; 30''.2, \qquad B' - B = -235° \; 0' \; 4''.63 \text{ ;}$$

and then equations (6 and 7) will give

$$\sin\phi = -0.4659954 + 0.1705154 = -0.2954800 \text{ ;}$$
$$\sin\phi = -0.1771443 - 0.1183358 = -0.2954801.$$

Therefore $\phi = -17° \; 11' \; 10''.8$; and equations (8) and (9) now give $\lambda - h = 47° \; 44' \; 34''.5$, $\lambda - h' = 80° \; 45' \; 46''.5$. Hence we get $\lambda = 195° \; 53' \; 52''.6$.

Therefore the second point on the earth's surface where the star's *Arcturus* and *Antares* would have the same relative distances from the zenith, as at Cleveland, at the same instant of absolute time, is situated in the Pacific ocean, about 200 miles to the westward of the New Hebrides Islands.

6. The formulas already given are sufficient for the astronomer to determine his own longitude and latitude on land; but for nautical purposes, tables may be easily prepared so as greatly to facilitate the application of the method in finding a ship's place at sea. Any two stars whose places are accurately known, are sufficient to determine the coordinates of the observer; but for the purposes of navigation, it seems best to select a few of the brightest stars and connect them by a system of triangulation, so that they may be conveniently observed in pairs, and properly distributed throughout the sky. And for the purpose of bringing the method to the notice of navigators, I have prepared a little list of twelve stars, as follows:

α Andromedae, *α Tauri*, *β Orionis*, *α Canis Majoris*. *α Canis Minoris*, *α Leonis*, *α Virginis*. *α Bootis*. *α Scorpii*, *α Lyrae*, *α Aquilae*, and *α Piscis Austrini*. The mean places of these stars for the beginning of 1893, are as follows:

This I designate as

TABLE I.

Star's Name		α	δ	sin δ	cos δ
		h m s	° ′ ″		
α Andromedae		0 2 51.4	+28 29 59	9.67866	9.94390
α Tauri	(*Aldebaran*)	4 29 46.8	+16 17 37	9.44803	9.98220
β Orionis	(*Rigel*)	5 9 23.7	— 8 19 32	9.16077*n*	9.99540
α Canis Majoris	(*Sirius*)	6 40 26.0	—16 34 11	9.45512*n*	9.98158
α Canis Minoris	(*Procyon*)	7 33 42.1	+ 5 29 56	8.98148	9.99800
α Leonis	(*Regulus*)	10 2 40.4	+12 29 24	9.33499	9.98960
α Virginis	(*Spica*)	13 19 33.3	—10 36 10	9.26482*n*	9.99252
α Bootis	(*Arcturus*)	14 10 46.8	+19 44 22	9.52859	9.97370
α Scorpii	(*Antares*)	16 22 50.8	—26 11 39	9.64485*n*	9.93294
α Lyrae	(*Vega*)	18 33 19.0	+38 41 3	9.79590	9.89243
α Aquilae	(*Altair*)	19 45 33.8	+ 8 35 9	9.17404	9.99511
α Piscis Austrini	(*Fomalhaut*)	22 51 14.3	—30 11 21	9.70145*n*	9.93670

These stars I have combined in pairs, each with the star immediately below; and have computed the corresponding values of A, B and c, as in the following

TABLE II.

Names of Stars		A	B	c	sin c	cos c
		° ′ ″	° ′ ″	° ′ ″		
α Andromedae	(*Aldebaran*)	65 55 58	85 44 35	62 9 13	9.94655	9.66941
(*Aldebaran*)	(*Rigel*)	21 42 55	157 34 43	26 29 56	9.69451	9.95189
(*Rigel*)	(*Sirius*)	72 24 4	112 34 48	23 40 37	9.60377	9.96181
(*Sirius*)	(*Procyon*	149 23 45	31 55 7	25 41 58	9.62714	9.95476
(*Procyon*)	(*Regulus*)	97 21 37	76 35 51	37 24 12	9.78349	9.90003
(*Regulus*)	(*Spica*)	65 57 5	113 9 59	54 3 17	9.90826	9.76865
(*Spica*)	(*Arcturus*)	156 19 29	22 36 51	32 51 32	9.73446	9.92428
(*Arcturus*)	(*Antares*)	38 12 44	143 51 51	56 0 22	9.91861	9.74749
(*Antares*)	(*Vega*)	149 22 22	26 18 28	71 41 42	9.97745	9.49703
(*Vega*)	(*Altair*)	25 30 28	146 56 32	34 11 41	9.74974	9.91757
(*Altair*)	(*Fomalhaut*)	56 43 30	133 2 34	59 9 3	9.93375	9.70993
(*Fomalhaut*)	*α Andromedae*	162 27 6	17 51 6	56 40 17	9.94221	9.73982

If such tables as the above were prepared from the *apparent* places of the stars at the middle of each month, and published in the *Nautical Almanac*, they would afford all needful facilities for the practical application of this method by mariners at sea.

7. We have seen in the example already computed, that formulas (6) and (7) give the same value for $\sin\phi$; and that (8) and (9) give the same value for λ; it is therefore unnecessary to employ duplicate formulas for these quantities. We shall therefore in what follows only make use of equations (5), (6) and (8) in the application of the method to practical examples, for the purpose of illustration.

We shall now suppose that we have the following zenith-distances of the stars *Vega* and *Altair*, made 1893 Sept. 14 at $14^h\ 26^m$ mean time at Greenwich; namely, $z = 50°\ 36'$, and $z' = 36°\ 24'$; the zenith and pole being on the same side of the great circle c. The computation may be conveniently arranged as follows:

Tab. II		(1)	$\cos c$	9.91757
		(2)	$\cos z$	9.80259
Tab. I		(3)	$\sin\delta$	9.79590
		(4)	$\cos\delta$	9.89213
		(5)	$\sin z$	9.88803
Tab. II		(6)	$\sin c$	9.74974
(1+2)	$= +0.52500$	(7)	log	9.72016
$\cos z'$	$= +0.80489$	(8)	log	9.90574
(8—7)	$= +0.27989$	(9)	log	9.44699
(5+6)		(10)	log	9 63777
(9—10) B'	$= \pm\ 49°\ 52'\ 20''$		cos	9.80922
Tab. II B	$=\ 146\ \ 56\ \ 32$			

$B'-B$	$= -97°\ 4'\ 12''$	(11)	cos	$9.09019n$
(4+5)		(12)	log	9.78046
(11+12)	$= -0.07424$	(13)	log	$8.87065n$
(2+3)	$= +0.39673$	(14)	log	9.59849
$\sin\phi$	$= +0.32249$		log	9.50852
ϕ	$= +18°\ 48'\ 50''$		sec	0.02384
$B'-B$			sin	$9.99669n$
z		(5)	sin	9.88803
$\lambda-h$	$= -54°\ 6'\ 33''$		sin	$9.90856n$

Sept. 14.	Sid. time at noon	$11^h\ 34^m\ 44^s.7$
	Mean time of observation	14 26 0.0
	Acceleration of sid. time	2 22.3
	Sid. time of obs.	$\mu = 26^h\ 3^m\ 7^s.0$
	Star's right-ascension	$\alpha = 18\ 33\ 19.0$

$$h = \mu - \alpha = 7^h\ 29^m\ 48^s.0 = 112°\ 27'\ 0''.0$$

Therefore $\lambda = h - 54°\ 6'\ 33'' = +58°\ 20'\ 27''$
$= 3^h\ 53^m\ 21^s.8$

The local mean time of observation was $14^h\ 26^m\ 0^s.0 - 3^h\ 53^m\ 21^s.8$ or $10^h\ 32^m\ 38^s.2$; and the place of observation was in longitude 58° 20′ 27″ west of Greenwich, and in latitude 18° 48′ 50″ north.

The second place at which the two stars were similarly situated at the same time can be found by means of a very little additional computation. For we have $B'-B = -196°\ 48'\ 53''$; and then $\sin\phi = -0.57740+0.39673 = -0.18067$. Therefore $\phi = -10°\ 24'\ 33''$, and $\lambda - h = +13°\ 8'\ 15''$, or $\lambda = +125°\ 35'\ 15'' = 8^h\ 22^m\ 21^s.0$; and the local mean time would be $6^h\ 3^m\ 39^s.0$; or about ten minutes after sunset.

8. The method here explained is entirely rigorous: and by it the latitude is determined with the same degree of precision as exists in the star places employed. The same thing may be said in regard to the longitude and local mean time, as referred to the meridian on which the star is situated at the time of the observations. The only source of error is that arising from the imperfection of the chronometer; but such errors are so small that they may safely be disregarded in voyages of several weeks' duration. But that source of error is inherent in the problem itself, and can best be partially rectified by the use of lunar distances. The necessary computations are short and easily made; not more that half an hour being required in order to completely determine the latitude, longitude and local time of the place of observation. Besides, no previous approximate knowledge in regard to the place of the ship is required, as in the usual methods of finding the place of a ship at sea. The list of stars to be employed may be indefinitely extended; any two of which, when properly observed, are equally serviceable for the purpose intended. The most delicate and difficult part of the calculations may be made by skilled computers and published in the *Nautical Ephemerides* for the benefit of navigators. The writer has already nearly completed the necessary computations for a list of thirty-two stars, giving somewhat more than a thousand combinations, and including all the stars of the first magnitude, and many of the second. By means of such an extended list of nautical stars, the navigator would have greater freedom of choice, and be enabled to select such pairs of stars as might be most conveniently situated for observation. It is therefore believed that the general adoption of this method by the commercial nations of the world would afford especial advantages to the navigator, and enable him to determine his place at sea with far greater precision than has heretofore been possible.

This method of using two stars for the determination of the latitude and the local time, when the longitude of the observer was given, has long been known; but the writer is not aware it has ever been applied to nautical purposes, for which it is apparently so well adapted.

Cleveland, Ohio, 1893 *September* 23.

THE CONSTANT OF ABERRATION AS DETERMINED FROM LATITUDE-OBSERVATIONS AT WAIKIKI.

By E. D. PRESTON.

The latitude-observations made last year at Waikiki, Hawaiian Islands, on the part of the U.S. Coast and Geodetic Survey, the results of which recently appeared in Bulletin No. 27, have, by permission of Superintendent **Mendenhall**, been rediscussed at the Washington Office, to determine the constant of aberration.

The method of dealing with these observations in a way to bring out in one system of equations both the variations of latitude and a correction to the constant of aberration was indicated by Professor **Newcomb**, at whose suggestion the discussion was undertaken.

The work involved the formation of a conditional equation for each individual latitude observed, giving for the entire series 2370 equations. These were treated in blocks which considerably diminished the labor of forming the normal equations. The period assumed for the revolution of the earth's axis of rotation about the axis of figure was 386 days, which comprises exactly the time during which the observations were continued.

The result is that the empirical formula for the periodic change of latitude agrees closely with that in Bulletin No. 27, which was deduced by the German method, and that the value of the aberration-constant is decreased from **Struve**'s value of 20″.445 to 20″.433. The probable error of this determination was 0″.034.

A Bulletin on the subject is now in course of publication by the Survey.

PHOTOGRAPH OF BROOKS'S NEW COMET (*c* 1893),

By E. E. BARNARD.

Though this comet was very low and mixed up with the northern part of the zodiacal light, I decided to hazard an exposure on it this morning with the Willard 6-in. portrait lens.

This exposure was from $4^h\,34^m$ a.m., the comet being followed with the guiding telescope.

The picture, although the exposure was short, and the comet very poorly placed, is a very successful one, and shows this object to possess characteristic features similar to those shown in the photographs made here of Swift's comet 1892 I.

The plate shows the tail to a distance of 3½°. This tail irregularly divides into two slightly divergent branches. There are two narrow straight rays springing out from the head on opposite sides and nearly symmetrical with the main tail. The north ray, which seems to leave the regim of the nucleus, is inclined to the body of the comet by about 45°; the southern, which leaves the comet 10′ or 15′ back of the head, is inclined about 30°. They are both about ½° long. There are faint evidences of several other rays from the southern side of the comet.

Mt. Hamilton, 1893 *Oct.* 19.

OBSERVATIONS OF COMET *c* 1893 (*BROOKS*),

MADE WITH FILAR MICROMETER OF 12-INCH EQUATORIAL OF THE LICK OBSERVATORY,

By E. E. BARNARD.

1893 Mt. Hamilton M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
Oct. 17 $16^h\,45^m\,27^s$	1	3	$-0^m\,14^s.02$	. . .	$12^h\,23^m\,9^s.54$	. . . .	$n9.681$	. . .
$16\;55\;21$	1	3	. . .	$-1'\,22''.2$	. . . .	$+13°\,39'\,17''.1$	. . .	0.702

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	$12^h\,23^m\,22^s.60$	$+0^s.96$	$+13°\,40'\,48''.0$	$-8''.7$	W.B. 12°355

$\Delta\alpha$ measured direct with micrometer. Comet bright, with nucleus and tail.

AT CATHOLIC UNIVERSITY, WASHINGTON, D.C.,

By Rev. GEO. M. SEARLE.

1893 Oct. 23 $22^h\,20^m\,23^s$ Greenw. M.T. App. $\alpha = 12^h\,31^m\,2^s.4$ App. $\delta = +17°\,35'\,29''$

Derived from comparison with F. 25 *Comae*, the position of which, M. Eq. 1893.0 $12^h\,31^m\,36^s.43$ $+17°\,40'\,44''.7$, was kindly furnished by Father **Hedrick**. The comet is very faint in the strong moonlight.

OBSERVATIONS OF COMET *c* 1893,

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

1893 Cincinnati M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			m s	′ ″	h m s	° ′ ″		
Oct. 18 16 58 30	1	5 , 5	−2 39.65	+4 11.6	12 24 20.47	+14 14 34.9	*n*9.672	0.715
19 16 45 40	2	10 , 10	−1 4.15	−1 54.7	12 25 37.46	+14 53 35.9	*n*9.675	0.719
21 16 53 19	4	7 , 7	−1 52.99	+0 29.0	12 28 17.99	+16 13 54.7	*n*9.675	0.707
23 16 48 30	5	12 , 12	−0 32.62	−4 54.3	12 31 3.78	+17 35 39.8	*n*9.678	0.702

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	12 26 59.16	+0.96	+14 10 32.3	− 9.0	B.B. VI, 14°2513
2	12 26 40.63	+0.98	+14 55 39.9	− 9.3	Equat. comparison with *3
3	12 31 39.04	. . .	+14 50 29.4	. . .	Weisse-Bessel (1) XII, 633
4	12 30 9.99	+0.99	+16 13 35.6	− 9.9	Weisse-Bessel (2) XII. 605–7. Rümk. 4036
5	12 31 36.39	+1.01	+17 40 44.6	−10.5	Pulk. 1899 ; Glas. 3216 ; 10-Yr. 1970 (25 *Comae*)

ELEMENTS AND EPHEMERIS OF COMET *c* 1893 (*BROOKS*),

BY J. G. PORTER.

I have just finished the following ephemeris of Comet *c*, based on elements from my own observations, sent you yesterday.

$$T = 1893 \text{ Sept. } 20.552 \text{ Berlin M.T.}$$

$$\left.\begin{aligned} \Omega &= 175^\circ\ 19'.3 \\ i &= 130\ \ 13.7 \\ \omega &= 350\ \ 40.2 \end{aligned}\right\} \text{M. Eq. } 1893.0$$

$$\log q = 9.91968$$

EPHEMERIS FOR BERLIN MIDNIGHT.

	α	δ	log Δ	log r
	h m s	° ′		
Oct. 26.5	12 34 41	+19 23.0	0.2111	0.0265
30.5	12 40 52	+22 19.8	0.1989	0.0145
Nov. 3.5	12 47 37	+25 28.0	0.1860	0.0626
7.5	12 55 3	28 48.9	.1729	.0806
11.5	13 3 19	32 24.0	.1597	.0982
15.5	12 35	36 14.3	.1470	.1155
19.5	23 8	40 19.9	.1355	.1324
23.5	35 20	44 39.9	.1250	.1468
27.5	13 49 42	+49 11.7	0.1169	0.1647

Cincinnati, October 27.

$$x = r[9.99916] \sin(v + 263^\circ\ 42'.7)$$
$$y = r[9.47162] \sin(v + \ \ 5\ \ 18.1)$$
$$z = r[9.98098] \sin(v + 352\ \ 36.8)$$

[The above elements show a striking resemblance to those of the comet 1864 I. — G.]

MT. HAMILTON OBSERVATIONS OF LAST CONTACT OF PARTIAL SOLAR ECLIPSE OF 1893 OCT. 9–10.

The sky was overcast till about noon. The following observations of contact II were secured.

Observer	Pacific S.T.	Instrument
	h m s	
J. M. SCHAEBERLE,	0 56 31.8	In focus of 40-foot Photoheliograph.
E. E. BARNARD,	0 56 29.6	12-inch refractor, "time of *tangency of limbs* at last contact; a large lump was visible one or two seconds longer."
R. H. TUCKER, JR.,	0 56 32.7	4-inch finder of 36-inch telescope.
A. L. COLTON,	0 56 21	3-inch portable telescope.
C. D. PERRINE,	0 56 33	In focus of 40-foot Photoheliograph.

Professor SCHAEBERLE and Mr. PERRINE secured seven negatives of the last half of the eclipse, with the photoheliograph.

EDWARD S. HOLDEN.

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MT. HAMILTON OBSERVATIONS OF LAST CONTACT OF PARTIAL SOLAR ECLIPSE OF 1893 OCT. 9–10, BY PROF. EDWARD S. HOLDEN.

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ON THE VARIATION OF LATITUDE, VIII.

By S. C. Chandler.

§1. Since the appropriation by the Trustees of the Watson Fund of the National Academy of Sciences, acknowledged in no. 267 of this Journal, I have received, and desire to make grateful acknowledgement of, a similar additional appropriation from the same source. This has enabled me to retain the skilled and invaluable services of Miss F. G. Wentworth. A part of the investigations thus undertaken have been published in the various papers in this Journal during the past two years. Others have been completed, and more are under way, but the topics of which they treat are so mutually related that a definite and connected statement of the results must be left to a future occasion. There are, however, one or two points, of extreme importance for the complete establishment of the theory of the latitude-variation, which have not yet been fully elucidated. It is to these that the present article is to be devoted.

In the beginning of these researches, about two years ago, especial attention was given to the question of the direction of the rotation of the pole (*A.J.*, XI, pp, 66, 70, 76). By comparison of simultaneous observations at three pairs of stations — Cambridge and Berlin, Washington and Pulkowa, Leyden and Melbourne — it was shown conclusively that this rotation was from West to East. At that time, however, I supposed the motion to be a simple one of 427 days' period. It was not until the summer of 1892 that it was discerned to be a complex one, composed of this and a superposed annual term. It then became necessary to re-examine the question of direction for each of the components. This was accordingly done, and satisfactory proof was found that both motions had the same direction, from West to East. This result was therefore adopted in all subsequent computations, but, as the proof of the proposition has not been anywhere given in the previous articles, being crowded out by topics more imperatively demanding statement, I now take the opportunity to go back to give an explicit demonstration, including all the data bearing upon it that are now available.

It is manifest that we should employ for this purpose series of observations made in widely different longitudes, and that each of them should be of sufficient extent to furnish independent values of the constants for both terms of the variation. But there are so few that fulfil the latter condition that I have felt at liberty to combine short series made in nearly the same longitude, first eliminating the quantities not common to both. In this way I have made the fourteen determinations of the numerical equations for the latitude-variation which are given in Table XIII. The constants were found by least-square solutions, uniformly on the principles developed in the first article on the Constant of Aberration, *A.J.* XII, pp. 177, 178. When two short series were combined, the xs were eliminated, and the summed elimination-equations solved for the other unknowns. A few words of description for each series will give all other needed explanation.

A. Peters's Vertical-Circle observations of *Polaris*, 1842–44. See eq. (39), *A.J.* 287.
B. The same for seven other stars. See *A.J.* 293, p. 33.
C. Struve's Prime-Vertical observations, 1840–55. See eq. (43), *A.J.* 296.
D. Gyldén's Vertical-Circle observations of *Polaris*, 1863–70. See eq. (41), *A.J.* 293.
E. Nyrén's Vertical-Circle observations of *Polaris*, 1871–75. See eq. (42), *A.J.* 293.
F. Nyrén's Prime-Vertical observations of four stars, 1875–79. See eq. (46), *A.J.* 297.
G. A combination of Nyrén's observations with the Prime-Vertical, 1879–82, with Küstner's by Talcott's method, 1884, 85.
H. Berlin observations by Talcott's method, 1889–92 April.
I. Greenwich Transit-Circle observations of four polars, 1880–91. See *Mo. Not. R.A.S.*, LIII, p. 119.
J. Washington Prime-Vertical observations of *α Lyrae*, 1862–67.

K. A combination of the Washington Prime-Vertical observations, 1882–84, with those at Cambridge with the Almucantar, 1884, 85.

L. Washington Transit-Circle observations of *Polaris*, 1880–87.

M. A combination of DOOLITTLE's observations by TALCOTT's method, 1890, and the similar ones of SMITH, 1891.

N. COMSTOCK's and BROWN's Meridian-Circle observations, 1883–90. The material used was taken from their table 6, *Mad. Obs.*, VI, part 4, pp. 108–119.

TABLE XIII.

Place	Ser.	Wt.		r_1	T'_1		r_2	G'
Pulkowa,	A	1	$\varphi_0-\varphi=$	$+0''.077$	$\cos(t-2\,394\,108)\,\theta$	$+$	$0''.122$	$\cos(\odot-377^\circ.5)$
"	B	1		. . . .	. . . .	$+$	$.215$	$\cos(\odot-312.8)$
"	C	1		$+\ .035$	$\cos(t-2\,394\,148)\,\theta$	$+$	$.100$	$\cos(\odot-327.7)$
"	D	3		$+\ .235$	$\cos(t-2\,402\,851)\,\theta$	$+$	$.166$	$\cos(\odot-304.4)$
"	E	3		$+\ .181$	$\cos(t-2\,405\,402)\,\theta$	$+$	$.088$	$\cos(\odot-313.5)$
"	F	3		$+\ .236$	$\cos(t-2\,407\,111)\,\theta$	$+$	$.227$	$\cos(\odot-360.0)$
Berlin,	G	2		$+\ .152$	$\cos(t-2\,408\,782)\,\theta$	$+$	$.114$	$\cos(\odot-303.5)$
"	H	3		$+\ .142$	$\cos(t-2\,411\,811)\,\theta$	$+$	$.164$	$\cos(\odot-357.0)$
Greenwich	I	2		$+\ .141$	$\cos(t-2\,409\,655)\,\theta$	$+$	$.148$	$\cos(\odot-300.0)$
Washington,	J	2		$+\ .127$	$\cos(t-2\,402\,203)\,\theta$	$+$	$.125$	$\cos(\odot-288.7)$
"	K	1		$+\ .120$	$\cos(t-2\,408\,549)\,\theta$	$+$	$.219$	$\cos(\odot-247.0)$
"	L	2		$+\ .236$	$\cos(t-2\,409\,561)\,\theta$	$+$	$.083$	$\cos(\odot-213.0)$
"	M	2		$+\ .098$	$\cos(t-2\,411\,718)\,\theta$	$+$	$.183$	$\cos(\odot-225.0)$
Madison,	N	1		$+0.152$	$\cos(t-2\,410\,382)\,\theta$	$+$	0.242	$\cos(\odot-182.3)$

Reducing all the above values of T'_1 to a common epoch (1875), by adding or subtracting multiples of the period 431 days, and taking the means by weights. for the equations in each longitude, for all the constants, we get:

FOURTEEN MONTHS' TERM.

Place	Wt.	r_1	O—C	T'_1	$\frac{\lambda}{\theta}$	T_1	O—C
		$''$	$''$		d		
Pulkowa,	11	0.188	+0.024	2 406 257	— 36	2 406 221	+22
Berlin,	5	.146	— .018	6 203	— 16	6 187	—12
Greenwich,	2	.141	— .023	6 207	0	6 207	+ 8
Washington,	7	.149	— .015	6 083	+ 92	6 175	—24
Madison,	1	0.152	—0.012	6 072	+107	6 179	—20
	26	0.164				2 406 199	

ANNUAL TERM.

Place	Wt.	r_2	O—C	G'	λ	G	O—C
		$''$	$''$	°	°	°	°
Pulkowa,	12	0.157	+0.004	320.5	—30.3	290.2	—13.7
Berlin,	5	.144	— .009	335.6	—13.4	322.2	+18.3
Greenwich,	2	.148	— .005	300.0	0.0	300.0	— 3.9
Washington,	7	.143	— .010	242.9	+77.0	319.9	+16.0
Madison,	1	0.242	+0.089	182.3	+89.4	271.7	—32.2
	27	0.153				303.9	

The fifth column, T'_1, gives the observed Julian date when the latitude would be a minimum, *i.e.*, when the pole of figure would pass the meridian of the respective stations by virtue of the fourteen months' revolution alone. As we pass from the Eastern to the Western stations it should decrease or increase, according as this revolution is from West to East or the reverse, by intervals proportional to the differences of longitude. Similarly G' is the sun's longitude on the observed date when the same phase would occur by virtue of the annual term alone, and should decrease or increase according as this revolution is from West to East or the reverse, respectively, by amounts equal to the differences of longitude. Now it will be seen that the above values of T'_1 and G' decrease from Pulkowa towards Madison, by amounts which are on the whole, considering the uncertainty of the data, generally consistent with the quantities $\frac{\lambda}{\theta}$ and λ in the sixth column. It is therefore proved beyond reasonable doubt that the direction of the rotations is from West to East in both elements; whence the general form of the equation for the variation of latitude adopted in *A.J.* 284, p. 154, eq. (19).

It may be thought that too much pains have been here bestowed upon a point which might be trusted to theory to decide. I cannot think so. One of the most salient results of these articles has been the proof of the fact that theory has been a blind guide with regard to the velocity of the polar rotation, obscuring truth and misleading investigators for a half a century. And even if we were certain, which we are not, that the fourteen months' term is the Eulerian period in a modified form, it would still be necessary to settle by observation the direction of the annual motion, with regard to which theory is powerless to inform us. To save repetition of argument, I must refer to the statement, in *A.J.* 273, pp. 68, 70, of the principles adopted in beginning these inquiries in 1891.

§2. The ground is now cleared for examination of the only topic remaining to be covered, to establish, upon the foundation of fact, every point in the present theory of these remarkable movements of the earth's axis. This is the question of the possibility that these movements are not real, but merely misinterpretations of the observed phenomena; being in whole or in part an illusory effect of instrumental error due to the influence of temperature. Such a possibility has been a nightmare in practical astronomy from the first, frightening us in every series of unexplained residuals, brought to light continually in nearly all attempts at delicate instrumental research. A source of danger so subtile could not fail to be ever present in the mind of every astronomer and physicist who has given even a superficial attention to the question of the latitude-variations, and there is no doubt that some are even now thus deterred from accepting these variations as proved facts. Perhaps the most explicit and forcible statement of the doubts that may arise on this subject has been given very recently by Mr. Cornu. The views of so distinguished a physicist, and of others who are inclined to agree with him, call for careful attention, and cannot be neglected in the present closing argument upon the theory presented in these articles.

It is unnecessary, for the purpose of disposing of objections of the sort raised by Cornu, to insist that it is not sufficient to show that the observed variations, attributed to the unsteadiness of the earth's pole, are near the limit of precision attainable in linear differential measures, and in the indication of the direction of gravity by means of the air-bubble of the level; or to show that there are known variations in divided circles and in levels, dependent on temperature and seasons. Nor need we require of objectors the difficult, although essential task — which they have not distinctly attempted — of showing that these errors are not eliminated, as they appear to be, by the modes in which astronomers use their instruments. Neither need we even urge the fact that a large portion of the data which have been utilized in the present researches on the latitude were derived by methods which dispense with levels, or with circles, a part of them indeed with both, and yet that the results of all are harmonious. On the contrary, let us admit, although merely for argument's sake, that all the known means of determining the direction of gravity — including the plumb-line, the level, and a fluid at rest, whether used for a reflecting surface or as a support for a floating instrument — are subject to a common law of periodical error, which vitiates the results of astronomical observation, obtained by whatever methods, and in precisely the same manner. Now the observed law of latitude-variation includes two terms, with periods of fourteen and twelve months, respectively. Since the phases of the first term are repeated at intervals of two months in successive years, and hence in a series of years come into all possible relations to conditions of temperature dependent on season, the argument against the reality of this term, on this ground, absolutely fails, and needs no further notice. As to the second, or annual term, while the phases, as observed in any given longitude, are indeed synchronical with the seasons, they are not so as regards different longitudes. If, therefore, the times of any given phase, as observed in the same latitude, but in successively increasing longitudes, occurred at the same date in all of them, there would be a fatal presumption against the existence of an annual period in the polar motion. If, on the contrary, they occur at times successively corresponding to the differences of longitude, the presumption is equally fatal to the hypothesis that they can possibly be due to temperature-variation as affecting instrumental measurement. But the facts given in the foregoing section correspond most distinctly to the latter condition. Therefore, unless additional facts can be brought to disprove successively these observed results, we may dismiss forever the bugbear which has undoubtedly led many to distrust the reality of the annual component of the latitude-variation, while they admit the existence of the 427-day term.

§3. It is not intended in this article to make a definitive determination of the coefficients. This task, and the discussion of their variations, must await a future occasion. I do not feel sure that any improvement could now be suggested to eq. (15), after putting $r_2 = 0''.16$, as on p. 153, *A.J.* 284, so that (15)

$$\begin{aligned}\varphi - \varphi_0 = -0''.12 \cos[\lambda + (t - 1875 \text{ Nov. } 1)\ 0^\circ.83527] \\ -0''.16 \cos(\lambda + \odot - 350^\circ)\end{aligned}$$

for the purpose of comparison with current observation, and prediction for the next few years of the probable course of the variations. The equation given by the mean values deduced on p. (160)—where the satisfactory accordance of the values at the different observatories, as shown by the columns O—C, may be noted in passing—is here written out, as follows: (47)

$$\begin{aligned}\varphi - \varphi_0 = -0''.164 \cos[\lambda + (t - 1875 \text{ Nov. } 6)\ 0^\circ.83527] \\ -0''.153 \cos(\lambda + \odot - 304^\circ)\end{aligned}$$

The agreement of these two equations is good, except for

G. The difference in this I cannot account for, but will merely say that I have reason to believe that this constant is subject to considerable fluctuation at different times. At the present time it seems evident that the larger value is nearer the observed one. As a compromise between the two equations we might take,

$$\begin{aligned}\varphi-\varphi_0 &= -0''.15\cos[\lambda+(t-1875\text{ Nov. }1)\,0^\circ.83527]\\ &\quad -0''.15\cos(\lambda+\odot-320^\circ)\end{aligned}\tag{48}$$

but it is doubtful whether it affords any improvement over (15) for the representation of current observation.

In any event, the small range of uncertainty here exhibited seems to show that we know, not only the general law of the latitude-variation, but also its constants with such accuracy that we may safely indulge in prediction as to its immediate future course: which is very soon to be marked by such singular and apparently erratic changes as to furnish, by comparison with observation, a most emphatic and crucial test of the theory. As illustration of this, I give below the computed times of the principal phases, for the Berlin meridian.

Computed Phases for Berlin.

Minimum		Maximum		Period from	
Date	Amplitude	Date	Amplitude	Min.	Max.
By Equation (15).					
	″		″		
1889 Feb. 10	—0.14	1889 Aug. 19	+0.20	383	386
1890 Feb. 28	— .24	1890 Sept. 9	+ .27	387	389
1891 Mar. 22	— .28	1891 Oct. 3	+ .27	387	387
1892 Apr. 14	— .25	1892 Oct. 24	+ .21	381	371
1893 Apr. 30	— .16	1893 Oct. 30	+ .10	350	317
(1894 Apr. 15)	(— .05)	(1894 Sept. 12)	(+ .04)	304	335
1895 Feb. 13	— .08	1895 Aug. 13	+ .14	371	380
1896 Feb. 19	—0.19	1896 Aug. 27	+0.24		
By Equation (48).					
1889 Jan. 12:	—0.20	1889 July 24	+0.25	389	391
1890 Feb. 5	— .28	1890 Aug. 19	+ .30	391	392
1891 Mar. 3	— .29	1891 Sept. 15	+ .27	393	395
1892 Mar. 30	— .22	1892 Oct. 14	+ .17	378	357
1893 Apr. 12	— .10	(1893 Oct. 6)	(+ .04)	385	367
(1894 Jan. 22)	(— .01)	(1894 Oct. 8)	(+ .06)	339	373
1894 Dec. 27	— .13	1895 July 8	+ .20	389	385
1896 Jan. 20	—0.29	1896 Aug. 6	+0.28		

An inspection of these data enables us to describe in general terms the probable course of the variations. The curve for 1892 will probably be the last for the present in which there will be any marked minima and maxima observable. The latter, in 1892 October, will show a perceptible decline from the height attained in the maxima of 1890 and 1891. The minimum of 1893 April will have a still smaller amplitude. Then will follow an interval of nearly two years, during which the fluctuations will be so slight as to make it difficult or impossible to fix the principal phases by observation; so that from the maximum of 1893 October to that of 1895 August, or from the minimum of 1893 April to that near the beginning of 1895, there will apparently be but a single decidedly marked period, of say 20–22 months. During this interval the variation will be confined within a total range of about 0″.10, as against 0″.56 which has prevailed between 1889 and 1892. In 1896 it will again attain nearly the same dimensions as in 1889, and from that time forward to 1898 it will be in full play, with the range of 0″.5 or 0″.6, and period of nearly 390 days, which prevailed between 1889 and 1892. After this the behavior from 1893 onward will be repeated, in obedience to the law of the seven-year cycle.

The above-described mutations pertain, of course, only to the operation of the short-period terms, and will be probably somewhat modified, as regards the described amplitudes, by the long-period variation indicated in *A.J.* 287, p. 178, and 293, p. 35.

I confidently await the verification to be afforded by the continuation of the current series of observations in various places, for vindication of the theory presented.

1893 *October* 27.

ON THE PARALLAX OF β *CYGNI*,

By F. L. CHASE.

In discussing the measures of the Rutherfurd photographic plates of the region about β *Cygni*, Mr. Harold Jacoby found that this star might possibly have a very large parallax. To furnish additional evidence on this interesting question, as soon as other work then in progress would permit, I began a short series of heliometer observations.

Two fairly symmetrical and well-situated pairs of comparison-stars were selected, whose position-angles from β *Cygni* were, in round numbers, 94° and 276° for the first pair, and 60° and 236° for the second pair. The distances of the four stars from β *Cygni* were observed on six evenings near each of the two epochs of maximum parallactic effect. Any progressive change in the scale-value during an evening was practically eliminated by observing in the order, say β 1, β 4, β 3, β 2, β denoting β *Cygni*, 1 and 4 the first pair of comparison-stars, and 2 and 3 the second pair. The mean of the distances β 1 and β 2 and that of β 3 and β 4 might thus be regarded as depending on the same scale-value. Care was taken to begin with a different distance each night, so as to equalize on the whole the refraction-corrections.

As a further test of any measured parallax, the companion of β *Cygni*, which I shall designate by β′, was similarly observed with reference to the same comparison-stars.

In the following table are given the resulting measures, in terms of revolutions of the micrometer-screw corrected for refraction and aberration, the mean temperature during observation, and the quality of seeing, expressed in the sharpness of the images and their steadiness, 1 meaning perfect, and 4 conditions too bad for observing to be possible.

Date	β 1	β′ 1	β′ 4	β 4	β 3	β′ 3	β′ 2	β 2	Tem.	Im.	St.
1893	r	r	r	r	r	r	r	r	°		
May 9	399.201	401.273	373.968	376.094	252.727	250.028	321.779	319.055	47	1–2	1–2
11	.188	.273	.965	.095	.722	250.079	.781	.061	54	2	2–3
18	.202	.241	.957	.065	.690	250.006	.746	.017	48	2	2–3
19	.224	.262	.937	.081	.695	250.011	.774	.050	47	2	2
29	.214	.239	.962	.069	.737	250.028	.755	.036	52	2–3	2–3
June 5	.200	.262	.950	.094	.686	249.996	.754	.057	68	. .	. .
Mean	399.2048	401.2583	373.9565	376.0830	252.7095	250.0247	321.7648	319.0460			
Oct. 2	399.185	401.253	373.908	376.051	252.712	250.018	321.740	319.067	55	3	3
5	.210	.247	.952	.065	.717	250.010	.765	.038	54	2	2
7	.194	.242	.929	.058	.729	250.032	.772	.049	55	2–3	2–3
8	.199	.244	.970	.104	.678	249.996	.750	.074	56	2	3
9	.192	.246	.936	.075	.718	250.017	.772	.053	62	3–4	3
10	.189	.247	.935	.060	.727	250.033	.768	.051	52	2–3	3
Mean	399.1948	401.2465	373.9383	376.0688	252.7152	250.0172	321.7612	319.0553			
" all ob.	399.1998	401.2524	373.9474	376.0759	252.7123	250.0210	321.7630	319.0506			

Assuming the mean of the sum $\frac{1}{2}(\beta 1+\beta 2)+\frac{1}{2}(\beta 3+\beta 4)$ to determine the standard scale-value, the excess of this mean sum over the observed sum on any night will give the correction which must be applied to each distance proportionally, to reduce them all to the same standard. The *differences* between $\frac{1}{2}(\beta 1+\beta 2)$ and $\frac{1}{2}(\beta 3+\beta 4)$, thus corrected, will on any night differ from an assumed value of this difference by the effect of the parallax of β plus the required correction to this assumed value. These sums and corrected differences are as follows:

	β *Cygni.*			β′ *Cygni.*		
1893	Sums	Differences	Corr. Diff.	Sums	Differences	Corr. Diff.
	r	r	r	r	r	r
May 9	673.5385	44.7175	44.7162	673.5240	49.5280	49.5257
11	.5330	.7160	.7151	.5490	.5050	.5008
18	.4870	.7320	.7341	.4750	.5120	.5132
19	.5250	.7490	.7486	.4920	.5440	.5440
29	.5280	.7220	.7214	.4920	.5020	.5020
June 5	.5185	.7385	.7386	.4810	.5350	.5358
Oct. 2	.5075	.7445	.7453	.4595	.5335	.5359
5	.5150	.7330	.7333	.4870	.5250	.5254
7	.5200	.7230	.7230	.4875	.5265	.5268
8	.5275	.7455	.7449	.4800	.5140	.5149
9	.5190	.7260	.7260	.4855	.5325	.5330
10	.5135	.7265	.7269	.4915	.5235	.5235
Mean	673.5194	44.7311	44.7311	673.4920	49.5234	49.5234

The parallax-factors for β *Cygni*, referred to the different comparison-stars, are

For $\beta\,1$, $0.979\,R\cos(\odot-194°\,44')$
" $\beta\,2$, $0.970\,R\cos(\odot-225\;\;35\;)$
" $\beta\,3$, $0.981\,R\cos(\odot-\;\;43\;\;20\;)$
" $\beta\,4$, $0.981\,R\cos(\odot-\;\;17\;\;33\;)$

The same factors were adopted for β', since its position-angle from each of the comparison-stars never differs by so much as 15′ from that of β.

Designating by x the correction to the mean corrected differences given in the above table, and by π the parallax sought, we form the following equations of condition and normals.

1893	For β	For β'
May 9	$x+1.802\,\pi=-0\overset{r}{.}0149$	$x+1.802\,\pi=+0\overset{r}{.}0023$
11	$x+1.778\quad=-0.0160$	$x+1.778\quad=-0.0226$
18	$x+1.686\quad=+0.0030$	$x+1.686\quad=-0.0102$
19	$x+1.670\quad=+0.0175$	$x+1.670\quad=+0.0206$
29	$x+1.491\quad=-0.0097$	$x+1.491\quad=--0.0214$
June 5	$x+1.343\quad=+0.0075$	$x+1.343\quad=+0.0124$
Oct. 2	$x-1.775\quad=+0.0142$	$x-1.775\quad=+0.0125$
5	$x-1.802\quad=+0.0022$	$x-1.802\quad=+0.0020$
7	$x-1.818\quad=-0.0081$	$x-1.818\quad=+0.0034$
8	$x-1.829\quad=+0.0138$	$x-1.829\quad=-0.0085$
9	$x-1.839\quad=-0.0051$	$x-1.839\quad=+0.0096$
10	$x-1.849\,\pi=-0.0042$	$x-1.849\,\pi=+0.0001$

NORMAL EQUATIONS.

$$\text{For }\beta\qquad \begin{aligned} +12.000x-\;\;1.142\pi&=+0\overset{r}{.}0002 \qquad [nn]=0.001\,450\\ +\;\;1.142x+35.916\pi&=-0.0481\end{aligned}$$

$$\text{For }\beta'\qquad \begin{aligned} +12.000x-\;\;1.142\pi&=+0.0002 \qquad [nn]=0.001\,991\\ +\;\;1.142x+35.916\pi&=-0.0677\end{aligned}$$

A solution of these gives

$$\text{For }\beta\qquad \pi=-0\overset{r}{.}0014\;\pm0\overset{R}{.}0013=-0\overset{''}{.}018\;\pm0\overset{''}{.}016$$, the probable error of one observation being $\pm0\overset{''}{.}109$

$$[vv]=0.001\,388$$

$$\text{For }\beta'\qquad \pi=-0.0019\;\pm0.0016=-0.024\;\pm0.020$$ " " " " " " ±0.116

$$[vv]=0.001\,861$$

The result obtained, especially considering the very satisfactory agreement with that for its companion, makes it seem highly probable that the parallax of β *Cygni* is extremely small.

No correction for proper motion has been applied; that of β *Cygni* being, according to AUWERS, only —0ˢ.0017 in A.R., and —0″.020 in Decl., and that of the comparison-stars presumably small, their magnitudes being respectively 7.0, 7.8, 8.1, and 7.8. Of course, to eliminate it rigidly, another set of observations would be necessary six months hence; but in view of the interest attaching to the question it has seemed advisable to publish the results already obtained.

Yale University Observatory, 1893 *October* 26.

ELEMENTS AND EPHEMERIS OF COMET *c* 1893 (*BROOKS*),

BY J. G. PORTER.

The accompanying elements of Comet c 1893 are computed from Cincinnati observations of October 18, 23 and 28. The middle place is represented exactly.

$$T = 1893 \text{ Sept. } 20.9836 \text{ Berlin M.T.}$$

$$\left.\begin{aligned}\Omega&=175°\,35'.3\\ i&=130\;\;22.\,6\\ \omega&=352\;\;\;\;3.8\end{aligned}\right\}1893.0$$

$$\log q = 9.92536$$

$$\begin{aligned} x&=r[9.99925]\,\sin(v+264°\,55'.6)\\ y&=r[9.47391]\,\sin(v+\;\;\;5\;\;46\,.6)\\ z&=r[9.98066]\,\sin(v+353\;\;53.\,9)\end{aligned}$$

EPHEMERIS FOR BERLIN MIDNIGHT.

	α	δ	log r	log Δ	Light
	h m s	° ′			
Nov. 3.5	12 47 36	+25 27.1	0.063	0.186	0.90
5.5	12 51 14	+27 5.9			
Nov. 7.5	12 55 3	+28 48.2	0.081	0.173	0.88
9.5	12 59 5	30 34.1			
11.5	13 3 21	32 23.7	0.098	0.159	0.86
13.5	7 51	34 17.0			
15.5	12 39	36 14.4	0.115	0.146	0.85
17.5	17 47	38 15.9			
19.5	23 16	40 21.0	0.131	0.134	0.83
21.5	29 10	42 29.8			
23.5	35 34	44 42.1	0.148	0.123	0.81
25.5	42 31	46 57.5			
27.5	50 7	49 15.5	0.163	0.115	0.78
29.5	13 58 29	51 35.3			
Dec. 1.5	14 7 42	+53 56.8	0.179	0.109	0.75

Observatory, Cincinnati, Oct. 3.

ELEMENTS OF COMET *c* 1893 (*BROOKS*),

BY REV. G. M. SEARLE.

Having obtained an observation of this comet here on Oct. 29, as follows:

Greenw. M.T.	App. α	App. δ
$21^h\ 54^m\ 30^s$	$12^h\ 39^m\ 59^s.20$	$+21°\ 53'\ 42''.6$

and combining this with the mean of the position obtained by Mr. WENDELL and myself on Oct. 17, and by Prof. PORTER and myself on Oct. 23, I made a computation to ascertain if there was any evidence of elliptical movement, as seemed possible from the similarity of the elements to those of comets 1864 I and 1822 I. It soon became manifest that any departure from a parabola indicated by the observations, which were corrected for parallax and aberration, would be slight, and toward a hyperbola, not an ellipse. Consequently it did not seem worth while to pursue the computation, but better to simply obtain a new parabola, which resulted as follows:

$$T = \text{Sept. } 19.5887 \text{ Greenw. M.T.}$$

$$\left.\begin{aligned} \Omega &= 175°\ \ 0'\ 36'' \\ \omega &= 348\ \ 21\ \ 45 \\ i &= 129\ \ 54\ \ 51 \end{aligned}\right\}\ 1893.0$$

$$\log q = 9.912764$$

As these elements differ but slightly from Prof. PORTER's, it is hardly necessary to give a new ephemeris; for his will undoubtedly serve for all practical purposes.

The discordances for the middle place (O—C) were $\Delta\lambda = +17''$, $\Delta\beta = -8''$, still indicating hyperbolic motion; but they are not important, as the comet, though quite bright, has not a very well marked nucleus, and its observed places cannot be expected to be very accurate.

FILAR-MICROMETER OBSERVATIONS OF COMET *c* 1893 (*BROOKS, Oct. 16*),

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY,

BY E. E. BARNARD.

1893 Mt. Hamilton M.T.	✱	No. Comp.	☄ — ✱ $\Delta\alpha$	☄ — ✱ $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Oct. 24 17 2 49	2	*3 , 5	+0 25.18	—1 55.9	12 32 28	+18 37.7	n9.685	0.665
26 16 47 32	3	*3 , 6	—0 29.86	+7 20.0	12 35 34.97	+19 46 53.0	n9.691	0.666
27 16 48 10	4	8 , 4	+0 47.32	+4 12.3	12 37 5.28	+20 30 24.6	n9.694	0.660

Mean Places for 1893.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
2	12 32 2	+1.03	+18 39.2	—11.0	9M; equatorial pointing
3	12 36 3.78	+1.05	+19 39 44.6	—11.6	W.B. XII, 723
4	12 36 16.89	+1.07	+20 26 24.3	—12.0	W.B. XII, 724

*Oct. 24, 26. $\Delta\alpha$ measured direct with micrometer.

PHOTOGRAPHS OF THE COMET.

Photographs made of this comet with the Willard lens, on Oct. 20, 21 and 22 seem to show that its tail encountered some disturbing influence on the 21st that shattered and distorted it in a most remarkable manner. The picture of the 22d showed a portion of the tail totally disconnected from the main tail, and apparently an independent comet. The position of this fragment at $16^h\ 40^m$ was

$$\alpha = 12^h\ 20^m, \qquad \delta = +20°$$

It was elliptical in form, and about $\frac{1}{2}°$ in diameter. Observations for position were also attempted on the above dates, but dawn prevented their completion after the photographs were made.

OBSERVATIONS OF COMET *c* 1893 (*BROOKS*),

MADE WITH THE FILAR-MICROMETER OF THE CINCINNATI EQUATORIAL,

BY J. G. PORTER.

1893 Cincinnati M.T.	✱	No. Comp.	☄ — ✱ $\Delta\alpha$	☄ — ✱ $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Oct. 28 16 27 51	1	12 , 12	+0 53.35	—2 57.1	12 38 26.42	+21 9 4.9	n9.689	0.695
30 16 22 2	2	10 , 10	+1 5.82	+1 24.6	12 41 36.78	+22 38 43.7	n9.694	0.690

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	12 37 31.98	+1.09	+21 12 14.4	—12.4	B.B. VI, 21°2449 and Berlin A.G.Z., 1 obs.
2	12 40 29.84	+1.12	+22 37 32.4	—13.3	Berlin A.G.Z., 3 obs.

COMET *b* 1893.

A telegram announces the rediscovery of this comet by Cerulli, Nov. 3, in the position given by the ephemerides. The equatorial heliocentric coordinates, as computed by Prof. Boss, are on p. 117. and from these Mr. Geo. E. Whitaker has computed the following ephemeris.

Gr. M.T.	App. α	App. δ	log Δ	Br.
	h m s	° ′ ″		
1893 Nov. 15.5	12 47 0.9	+0 4 26		
16.5	47 2.2	0 2 43		
17.5	47 2.8	+0 1 6	0.4721	0.092
18.5	47 2.4	—0 0 24		
19.5	47 1.2	0 1 48		
20.5	46 59.1	0 3 6		
21.5	46 56.1	0 4 17	0.4707	0.088
22.5	46 52.3	0 5 21		
23.5	46 47.5	0 6 19		
24.5	46 41.8	0 7 10		
25.5	46 35.2	0 7 54	0.4686	0.085
26.5	46 27.6	0 8 32		
27.5	46 19.0	0 9 2		
28.5	46 9.4	0 9 25		
29.5	45 58.8	0 9 41	0.4661	0.083
30.5	45 47.1	0 9 49		
Dec. 1.5	45 34.4	0 9 50		
2.5	45 20.5	0 9 44		
3.5	45 5.5	0 9 30	0.4630	0.080
4.5	44 49.4	0 9 7		
5.5	44 32.1	0 8 37		
6.5	44 13.6	0 7 59		
7.5	43 53.9	0 7 13	0.4594	0.078
8.5	12 43 33.0	—0 6 19		
1893 Dec. 9.5	12 43 10.8	—0 5 16		
10.5	42 47.3	0 4 4		
11.5	42 22.5	0 2 44	0.4554	0.077
12.5	41 56.4	—0 1 16		
13.5	41 28.9	+0 0 22		
14.5	41 0.0	0 2 8		
15.5	40 29.8	0 4 3	0.4511	0.076
16.5	39 58.2	0 6 7		
17.5	39 25.1	0 8 21		
18.5	38 50.5	0 10 43		
19.5	38 14.5	0 13 15	0.4465	0.074
20.5	37 37.0	0 15 56		
21.5	36 58.0	0 18 47		
22.5	36 17.5	0 21 48		
23.5	35 35.4	0 24 58	0.4417	0.073
24.5	34 51.8	0 28 17		
25.5	34 6.6	0 31 47		
26.5	33 19.8	0 35 27		
27.5	32 31.3	0 39 16	0.4367	0.072
28.5	31 41.2	0 43 15		
29.5	30 49.4	0 47 25		
30.5	29 56.0	0 51 45		
31.5	12 29 1.0	+0 56 15	0.4317	0.072

Brightness Nov. 9 = 0.100.

NUMERATION OF ASTEROIDS DISCOVERED IN 1893.

Numbers have recently been assigned to twenty-one of these bodies, discovered between January 12 and August 19.

To seven others, found during the same interval, no numbers are assigned, for want of sufficient observations to permit the computation of elliptic orbits.

These are 1893 *C, D, M, O, U, X, Y*.

The planet 1893 *Q* has been found identical with (104) *Clymene*, for which the value of φ in the *Berliner Jahrbuch* requires an increase of 30′; *Z* with (175) *Andromache*, *AF* with (158) *Coronis*; and *AG* with (107) *Camilla*.

The numbers assigned by the *Recheninstitut* are

1893				1893			
B	Jan. 12	Wolf	(352)	*S*	Mar. 17	Charlois	(363)
F	16	"	(353)	*T*	19	"	(364)
A	17	Charlois	(354)	*V*	21	"	(365)
E	20	"	(355)	*W*	21	"	(366)
G	21	"	(356)	*AA*	May 19	"	(367)
J	Feb. 11	"	(357)	*AB*	19	"	(368)
K	Mar. 8	"	(358)	*AE*	July 4	Borrelly	(369)
L	9	"	(359)	*AC*	14	"	(370)
N	11	"	(360)	*AD*	16	"	(371)
P	11	"	(361)	*AH*	Aug. 19	"	(372)
R	12	"	(362)				

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Elements of Comet c 1893 (Brooks), by Rev. G. M. Searle.
Observations and Photographs of Comet c 1893 (Brooks, Oct. 16), by Prof. E. E. Barnard.
Observations of Comet c 1893 (Brooks), by Prof. J. G. Porter.
Comet b 1893.
Ephemeris by Mr. George E. Whitaker.
Numeration of Asteroids Discovered in 1893.

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NOTES ON VARIABLE STARS. — No. 1.

By HENRY M. PARKHURST.

My observations of variable stars of long period, for ten years from 1883 to 1892 inclusive, reduced to the photometric scale, are given in Vol. XXIX of the Annals of the Harvard College Observatory.

The photometric scale employed by me for the last thirty years (see PARKHURST'S *Astronomical Tables*, pp. 182 and 229), is based upon POGSON'S ratio of 2.512. My aperture being nine inches, this will show a star of $14^{M}.0$; but this needs a high power, a small zenith-distance, and an exceptionally clear sky.

By reference to the Catalogue of Comparison-Stars accompanying my first ten years of observations, (*H.C.O. Annals*, Vol. XXIX), the preliminary magnitudes of most of the comparison-stars may be ascertained, and the photometric scale determined. By comparison with the scale of magnitudes used in the Second Catalogue, it will be seen that there is a large variation between the two, especially between the ninth and the twelfth magnitude, the photometric scale making these stars apparently much fainter. Forty-seven $9^{M}.0$ DM. and SD. stars average $9^{M}.42$ photometric. Fifty-nine of the best determined $9^{M}.5$ DM. stars average $10^{M}.69$ photometric; 19 of the best determined $9^{M}.9$ and $10^{M}.0$ SD. stars average $10^{M}.86$ photometric.

Part of this variation undoubtedly arises from the inclusion, both in the DM. and in the SD. catalogues, of many stars somewhat below the lower limit previously fixed.

Commencing with the present year, I have obtained the following results, in which, following the Julian date (omitting for brevity the first three figures), are given the number of periods, *E*, reckoned from the epoch, and the variation in days, from the elements contained in CHANDLER'S Second Catalogue, in No. 300 of the *Astronomical Journal*.

RESULTS OF OBSERVATION.

No	Star	Phase	Observed Date		E	Corr.	Remarks
			Julian	Calendar			
432	*S Cassiopeae*	Max.	2564	1893 Apr. 10	18	$+30^{d}$	
1717	*V Tauri*	Min.	2454	1892 Dec. 21	44	— 6	
	"	Max.	2537	1893 Mar. 14	"	—12	
1923	*S Aurigae*	Max.	2528	Mar. 5	–	–	A period of 600 days, with an irregularity of at least 60 days, appears to be a rude approximation.
1986	*T Orionis*	Max.	2517	Feb. 22	–	–	Near the predicted minimum for the assumed period of 225 days, the only period which seemed plausible.
2266	*V Monocerotis*	Max.	2503	Feb. 8	11	— 8	
2539	*R Canis minoris*	Max.	2546 :	Mar. 23	37	— 9	
2684	*S Canis minoris*	Max.	2547	Mar. 24	33	0	
2691	*T Canis minoris*	Max.	2540 :	Mar. 17	26	—12	No appreciable change for 30 days.
2735	*U Canis minoris*	Min.	2561	Apr. 10	12	+59	Fell 2 magnitudes, after the predicted time.
2742	*S Geminorum*	Max.	2553	Mar. 30	51	+13	
2780	*T Geminorum*	Max.	2503 :	Feb. 8	56	0	But I did not commence observing until this date, and found no change for 26 days following.
2815	*U Geminorum*	–	–	–	–	–	Invis. from 2529^{d} to 2565^{d}, including the predicted max.
3060	*U Cancri*	Max.	2574	Apr. 20	48	+ 2	
3994	*S Leonis*	Max.	2509 :	Feb. 14	62	— 1	
4377	*T Virginis*	Min.	2634 :	June 19	35	+30	May have been later. Assumes minimum midway.
4492	*Y Virginis*	Max.	2600	May 16	17	0	
4596	*U Virginis*	Max.	2516	Feb. 21	47	+ 9	
5037	*RR Virginis*	Max.	2257	1892 June 7	22	0	In 1893 variable had not appeared, 37 days prior to predicted maximum.
5070	*Z Virginis*	–	–	–	–	–	In 1893 had not appeared, 49 days prior to pred. max.
5338	*U Bootis*	Max.	2543	1893 Mar. 20	27	— 2	
	"	Min.	2629	June 14	28	—14	

No.	Star	Phase	Observed Date Julian	 Cal. date	E	Corr.	Remarks
	U Bootis	Max.	2718	1893 Sept. 11	28	-5^{d}	These are the corrections derived from my lengthening period suggested in the note to the Catalogue.
5438	*Y Librae*	Max.	2682 :	Aug. 6	36	—39	Maximum possible earlier. A period of 326 days suggested.
5494	*S Librae*	Max.	2609	May 25	36	— 6	
5583	*X Librae*	Max.	2598	May 14	33	+16	
"	"	"	"	"	48	0	From my own elements suggested in note to the Catal.
5617	*U Librae*	Max.	2599	May 15	32	— 2	From photom. obs., rejecting visual comp. May 7.
5677	*R Serpentis*	Max.	2742	Oct. 5	69	—21	
5761	*Z Scorpii*	Max.	2688	Aug. 12	20	+22	A period of 369 days satisfies the last three maxima, but does not fit older observations so well.
5795	*W Scorpii*	Max.	2625 :	June 10	28	0	Began observations June 12, and found it diminishing.
5831	*S Scorpii*	Max.	2676	July 31	116	+16	No correction of elements needed.
5887	*V Ophiuchi*	Max.	2627 :	June 12	23	—25	See remarks below.
"	"	Max.	2627 :	June 12	23	+ 6	From my elements below.
"	"	Max.	2658	July 13	23	0	" " " "

5887. Probably earlier. At periods 11, 12, 13, 18, and 22, there appear to have been maxima observed 30 or 40 days later. At 11 and 22, both are recorded. I therefore continued the observation, although the variable had fallen $0^{M}.4$, and observed a second maximum at 2658, Jan. 13. Making the epoch 2 605 652, and the period 303 days, and a secondary maximum 37 days later, sometimes mistaken for the principal maximum, explains the principal discrepancies in the observations. The secondary maximum nearly equals, and possibly may sometimes exceed, the first.

The individual observations, upon which my results are based, will be given in compact form as in the following table. In each column there are given, first the two dates for each observation, omitting as before the first three figures, and secondly, the observed magnitude upon the scale already described. When the magnitudes are given only to one place of decimals, it indicates a visual comparison upon ARGELANDER's plan, with comparison-stars whose photometric magnitudes had previously been observed. When two places of decimals are given, it indicates photometric observation,—a single observation consisting of two extinctions of the variable, and a suitable number of extinctions of comparison-stars. An inferior 2, following a photometric magnitude, indicates four extinctions of the variable, and usually sixteen extinctions of comparison-stars. Occasionally more than four extinctions of the variable were observed, as indicated by the inferiors appended. When a variable could not be seen, the magnitude is given of the faintest visible comparison-star, sometimes reduced several tenths by estimation, in order to show the condition of the sky and the telescope, making it certain that the variable was less than the magnitude stated. In this case the magnitude is followed by a reversed bracket. Thus, 12.0] indicates that if the variable had been of the 12.0 magnitude it would have been seen. Sometimes, from the absence of faint comparison-stars, the limit thus fixed is undoubtedly much too bright.

INDIVIDUAL OBSERVATIONS.

432 *S Cassiopeae*

Julian	Calendar	Mag.
d	1893	
2483	Jan. 19	10.2
2552	Mar. 29	8.8
2556	Apr. 2	9.2
2569	15	8.5
2577	23	9.2

1717 *V Tauri*

Julian	Calendar	Mag.
2472	Jan. 8	12.8]
2480	16	12.8]
2484	20	12.9
2498	Feb. 3	12.0
2509	14	10.8
2511	16	10.8
2515	20	11.1
2517	22	10.6
2529	Mar. 6	10.5
2535	12	10.5

1717 *V Tauri*— Cont.

Julian	Calendar	Mag.
d	1893	
2536	Mar. 13	9.72_2
2539	16	9.95_2
2541	18	$9\ 91_2$
2543	20	10.4
2544	21	10.08_2

1923 *S Aurigae*

Julian	Calendar	Mag.
2485	Jan. 21	11.0
2530	Mar. 7	10.2
2558	Apr. 4	10.5

1953 *T Aurigae*

Julian	Calendar	Mag.
2485	Jan. 21	10.7
2530	Mar. 7	10.9
2558	Apr. 4	10.8

1986 *T Orionis*

Julian	Calendar	Mag.
d	1893	
2498	Feb. 3	11.0
2509	14	10.3
2529	Mar. 6	10.2
2535	12	11.0]
2544	21	11.2

2266 *V Monocerotis*

Julian	Calendar	Mag.
2498	Feb. 3	6.3
2503	8	6.0
2509	14	6.3
2511	16	6.5
2515	20	6.8
2517	22	6.8
2522	27	7.0
2524	Mar. 1	6.87_2
2525	2	6.98_2

2266 *V Monoc.*— Cont.

Julian	Calendar	Mag.
d	1893	
2530	Mar. 7	7.31
2551	28	8.8

2539 *R Canis minoris*

Julian	Calendar	Mag.
2505	Feb. 8	8.8
2529	Mar. 6	8.1
2544	21	8.2
2556	Apr. 2	8.0
2559	5	8.24_2

2625 *V Geminorum*

Julian	Calendar	Mag.
2498	Feb. 3	10.0

2684 *S Canis minoris*

Julian	Calendar	Mag.
2503	Feb. 8	8.0
2509	14	8.1

2684 *S Can. min.*—Cont.

Julian	Calendar	Mag.
d	1893	
2511	Feb. 16	8.1
2515	20	8.4
2526	Mar. 3	7.83_2
2536	13	8.03_2
2544	21	7.50_2
2556	Apr. 2	7.87_2

2691 *T Canis minoris*

Julian	Calendar	Mag.
2503	Feb. 8	11.9
2529	Mar. 6	11.6
2536	13	11.6
2544	21	11.0]
2558	Apr. 4	11.6
2560	6	11.62_2
2570	16	11.94_2
2590	May 6	11.9
2591	7	11.90 :

2735 *U Canis minoris*

Julian	Calendar	Mag.
d	1893	
2503	Feb. 8	10.8
2529	Mar. 6	11.3
2544	21	11.1]
2558	Apr. 4	12.9
2569	6	13.0
2570	16	12.9
2590	May 6	11.0
2591	7	11.57_2

2742 *S Geminorum*

Julian	Calendar	Mag.
2503	Feb. 8	9.6
2529	Mar. 6	9.2
2539	16	9.3
2541	18	9.4
2544	21	9.2
2556	Apr. 2	9.03_2
"	2	9.3
2558	4	9.49_2
2560	6	9.29_2
2565	11	9.67_2

2780 *T Geminorum*

Julian	Calendar	Mag.
2503	Feb. 8	8.8
2509	14	8.8
2511	16	8.8
2515	20	8.8
2529	Mar. 6	8.8
2539	16	9.2
2544	21	9.5

2815 *U Geminorum*

Julian	Calendar	Mag.
2529	Mar. 6 to	
2565	Apr. 11	11.7]
	11 dates	

3060 *U Canis minoris*

Julian	Calendar	Mag.
2509	Feb. 14	12.2]
2530	Mar. 7	12.2]
2544	21	10.2]
2558	Apr. 4	11.2
2559	Apr. 5	11.21_3
2565	11	10.61_2
2570	16	10.33_2
2572	18	9.81_2
2577	23	10.20_2

3994 *S Leonis*

Julian	Calendar	Mag.
2509	Feb. 14	11.0
2511	16	11.1
2515	20	11.3
2530	Mar. 7	11.3

4377 *T Virginis*

Julian	Calendar	Mag.
2530	Mar. 7	11.0]
2536	13	12.0
2558	Apr. 4	12.8:
2570	16	12.9:
2623	June 8	12.5]
2627	12	12.8]
2646	July 1	12.0]
2647	2	12.0]

4492 *Y Virginis*

Julian	Calendar	Mag.
2517	Feb. 22	11.5]
2530	Mar. 7	11.0]
2536	13	12.5]
2558	Apr. 4	12.2
2559	5	12.00
2565	11	12.1
2570	16	11.3
2572	18	11.33_2
2577	23	10.50_2
2590	May 6	9.7
2591	7	9.50_2
2593	9	9.53_2
2596	12	9.31_2
2603	19	9.32_2
2608	24	9.56_2
2614	30	9.55_2
2623	June 8	9.82_2

4596 *U Virginis*

Julian	Calendar	Mag.
d	1893	
2511	Feb. 16	8.6
2517	22	8.5
2530	Mar. 7	9.0

5037 *RR Virginis*

Julian	Calendar	Mag.
2623	June 8	12.5]
2646	July 1	12.7]
2647	2	12.7]
2654	9	12.7]

5070 *Z Virginis*

Julian	Calendar	Mag.
2623	June 8	12.6]
2646	July 1	12.6]
2647	2	12.6]
2654	9	12.6]

5338 *U Bootis*

Julian	Calendar	Mag.
2517	Feb. 22	11.1
2536	Mar. 13	10.4
2544	21	10 2
2558	Apr. 4	10.5
2570	16	10.9
2572	18	11.2
2590	May 6	11.5
2623	June 8	12.7
2627	12	12.82_2
2633	18	12.85_2
2635	20	12.32_2
2668	July 23	12.16_2
2701	Aug. 25	11.42_2
2705	29	11.23_2
2713	Sep. 6	11.25_2
2719	12	10.82_2
2723	16	11.18_2
2737	30	11.60_2

5438 *Y Librae*

Julian	Calendar	Mag.
2681	Aug. 5	10.3
2682	6	10.22_2
2683	Aug. 7	10.30_2
2689	13	10.48_2
2706	30	11.38_2

5494 *S Librae*

Julian	Calendar	Mag.
2590	May 6	8.7
2603	19	8.86_2
2608	24	8.41_2
2615	31	8.83_2

5583 *X Librae*

Julian	Calendar	Mag.
2590	May 6	12.1
2591	7	11.85_2
2593	9	12.0
2594	10	11.86_2
2603	19	11.85_2
2608	24	12.0
2615	31	12.2
2616	June 1	12.47_2

5617 *U Librae*

Julian	Calendar	Mag.
2591	May 7	9.6
2593	9	9.7
2594	10	9.77_2
2603	19	9.66_2
2608	24	9.88_2
2615	31	9.74_2
2616	June 1	10.26_2

5677 *R Serpentis*

Julian	Calendar	Mag.
2647	July 2	12.5
2694	Aug, 18	9.5
2702	26	9.43_2
2713	Sep. 6	8.54_2
2724	17	7.58_2
2739	Oct. 2	6.98_2
2749	12	7.39_2
2762	25	7.41_2

5761 *Z Scorpii*

Julian	Calendar	Mag.
d	1893	
2627	June 12	12.5
2633	18	12.48_2
2647	July 2	12.11_2
2654	9	11.77_2
2660	15	11.29_2
2664	19	11.17_2
2675	30	10.47_2
2679	Aug. 3	10.9
2681	5	10.18_2
2684	8	10.38_2
2687	11	10.08_2
2689	13	10.15_2
2691	15	10.27_4

5795 *W Scorpii*

Julian	Calendar	Mag.
2627	June 12	11.9
2633	18	12.1

5830 *R Scorpii*

Julian	Calendar	Mag.
2627	June 12	12.1
2647	July 2	to
2685	Aug. 9	13.0]

5831 *S Scorpii*

Julian	Calendar	Mag.
2627	June 12	13.0]
2647	July 2	12.5
2652	7	12.25_2
2655	10	11.71_2
2661	16	11.87_2
2666	21	11.58_2
2678	Aug. 2	11.31_2
2682	6	11.48_2
2685	9	11.68_2

5887 *V Ophiuchi*

Julian	Calendar	Mag.
2627	June 12	7.9
2633	18	7.94_2
2645	30	8.24_2
2652	July 7	8.29_2
2661	16	8.03_2
2668	23	8.50_2

5761, 2679. Haze.

OBSERVATIONS OF THE *GEGENSCHEIN* OR ZODIACAL COUNTERGLOW,

MADE AT THE LICK OBSERVATORY DURING SEPTEMBER AND OCTOBER, 1893,

By E. E. BARNARD.

In the *Astronomical Journal*. no. 168, p. 186, I have given a list of observations of the '*Gegenschein*,' made at Nashville, Tennessee, 600 feet above the sea, and which were obtained between the years 1885 and 1887. And in no. 243, p. 19, of the same Journal, a further list is given, extending from 1888 to 1891, and made at Mt. Hamilton, 4200 feet above the sea.

In these two papers are given the observed positions of the '*Gegenschein*,' and its deviations, both from the ecliptic and from a point in exact opposition to the sun.

Several facts concerning this singular object were there brought forth which were not previously known. One of these was its regular change of form after having passed the vernal equinox; the other, the fact that its mean longitude is slightly less than ☉ + 180°, or in other words, it is not quite opposite the sun in longitude — the mean of the observations always placing it a little less than exact opposition. It was previously known that the '*Gegenschein*' is always placed a little north of the ecliptic. Observations made the present year confirm all these facts.

In this *Journal*, no. 243, p. 90, I called attention to the need of observations made in the southern hemisphere to settle the question whether the northern latitude of the '*Gegenschein*' might not be an effect produced by atmospheric absorption. It is to be hoped that the present year will settle this question.

At the request of Professor E. C. Pickering, Professor Baily has been making observations of the position of the '*Gegenschein*' during September and October past at Arequipa, and in conjunction with his observations I have made similar ones here. Part of this period was also covered by Professor Arthur Searle, at Strafford, Vermont, the summer home of Dr. Chandler. Professor Searle was fortunate in securing good observations during the time his visit to Strafford permitted. It is too early yet to hear from Professor Baily, but doubtless he has secured good observations, as he will have had clear weather at Arequipa, which will have assured him good opportunities to observe this phenomenon from a favorable station.

My present observations have been made with the greatest care, and their close agreement with the condition of exact opposition is remarkable, considering the diffuse and indefinite nature of the phenomenon.

In determining the position of an object like the '*Gegenschein*,' it is easy to make an error of two or three degrees in the location of its center, unless special care is taken. However, when great pains are taken, it can nearly always be located to within one degree. In fixing its center, one has to study it very carefully, and it very often takes from a half to three-quarters of an hour before one is certain just where its center is. Here this is done on the house top, where no light can strike the eye. It is necessary to exclude the bright stars and planets from the view by a shield of some kind. When finally one is certain of its location, it is referred to some faint star near it. If this star is more than three or four degrees distant, the position of the center of the '*Gegenschein*' is fixed in the mind, and the 12-inch is pointed exactly to it by sighting along the tube, and the resulting place determined from the pointings.

Professor Searle has given an excellent method of observing such objects, in the *Astr. Nachr.*, no. 3155. However, I think the method I have followed above will give perhaps the most satisfactory results for the '*Gegenschein*,' since one will be locating its center in the sky, and is not troubled by frequent reference to a lantern and map from which the center is afterwards to be determined from contour lines.

I have not at any time during these observations known just where the '*Gegenschein*' should be — that is, I have kept myself from any knowledge of the point of the sky exactly opposite the sun. The observations, also, have not been reduced until the moon has closed observations for the month. They are therefore distinctly free from any prejudice in that respect. Indeed, when carefully observed, I do not think one could be prejudiced in locating the '*Gegenschein*' by a previous knowledge of just where it ought to be, if he is used to observing it, because of the small uncertainty in determining the position of its center. A displacement of as much as two degrees, ordinarily, would be offensively out.

Following are the observations which I have obtained of the position of the center of the '*Gegenschein*' during September and October of this year. *Jupiter*, the Pleiades, and the Milky Way, will prevent any further observations during 1893.

Observed Positions of the Center of the *Gegenschein*, made at Mt. Hamilton, Lick Observatory, California.

Mt. Hamilton M.T.		α	δ	λ	β	λ—☉	Δ
1893	h m	h m	°	°	°	°	°
Aug. 31	8 24	22 45	— 8.2	339.6	—0.2	180.7	+0.7
Sept. 1	8 54	22 47	— 8.2	340.1	+0.4	181.9	+1.9
2	9 14	22 47	— 7.2	340.5	—0.6	179.5	—0.5
3	10 8	22 53	— 6.9	341.9	+0.2	180.0	0.0
8	11 4	23 1	— 3.6	345.2	+2.9	178.5	—1.5
9	11 14	23 9	— 4.6	346.5	+0.7	178.7	—1.3
9	13 54	23 21	— 3.8	349.5	+0.3	181.6	+1.6
13	10 24	23 25	— 3.1	350.8	+0.6	179.1	—0.9
13	12 27	23 26	— 3.4	350.8	+0.2	179.1	—0.9
15	10 9	23 35	— 2.7	353.2	0.0	179.6	—0 4
16	11 15	23 33	— 1.5	353.2	+1.3	178.6	—1.4
18	11 54	23 49	— 0.5	357.3	+0.6	180.7	+0.7
20	14 9	23 55	+ 1.3	358.4	+0.6	179.7	—0.3
Oct. 1	9 33	0 30	+ 3.5	8.3	+0.2	179.1	—0.9
3	9 53	0 41	+ 3.3	10.7	—1.0	179.5	—0.5
4	11 48	0 43	+ 4.8	11.8	+0.2	179.5	—0.5
6	10 12	0 49	+ 6.0	13.6	+1.3	179.3	—0.7
7	10 53	0 57	+ 5.8	15.4	—0.3	180.1	+0.1
9	9 18	0 57	+ 7.3	16.6	+0.8	179.5	—0.5
11	12 23	1 8	+ 8.0	18.7	+0.7	179.5	—0.5
16	12 28	1 24	+10.8	23.4	+1.8	179.3	—0.7
18	12 23	1 29	+10.8	24.5	+1.4	178.3	—1.7
		Mean			+0.5		—0.4

Δ is the difference, greater or less, than (λ—☉) = 180°

It will be well here to briefly state again a few of the facts that have been brought forth during my observations, which extend over an interval of ten years.

In July the '*Gegenschein*' is small and round, less than 10° in diameter. After crossing the Milky Way in the *Scorpion* and *Sagittarius* it is largest — some 20° in diameter; round, and gradually brighter in the middle; dense and hazy. It is then not connected with any zodiacal band. It remains thus without special change until September and October, when near the vernal equinox. Here it becomes elongated along the ecliptic, and is connected with a narrow zodiacal band, which is some 4° in width. After this the '*Gegenschein*' narrows down very much, until by November and February it is reduced to simply a swelling and intensification of the zodiacal band, and is only 5° or 6° in breadth, north and south; and in general it remains thus until in April. At two points in its path it is lost in the Milky Way — in *Sagittarius* and in *Gemini*.

The '*Gegenschein*' is always sensibly, but very gradually brighter in the middle. It never has the appearance of nebulous matter, but looks as if it were light reflected from infinitely small particles of dust. In connection with the appearance of this object, and my statement that it is gradually brighter in the middle, I understand that Professor

W. H. **Pickering** saw it at Arequipa as a large annulus — a ring of light with a dark center. Besides the changes of form, and its connection with a zodiacal band, I think my observations pretty conclusively show that the '*Gegenschein*' lags behind a point exactly opposite the sun, *i.e.* its longitude is less than 180° greater than the sun's longitude. For if we take the means of these quantities for the different series of observations which I have published, we have

From 1883 to 1887	$\lambda - \odot = 179^\circ.4$	16 observations
From 1888 to 1891	$\lambda - \odot = 179\ .4$	16 "
Sept. and Oct. 1893	$\lambda - \odot = 179\ .6$	22 "

It is just possible that this peculiarity is due to atmospheric absorption, as the majority of the observations have been made to the east of the meridian, where the absorption of the air would have a tendency to make the center of brightness less in longitude than it really was.

As I have previously said, my observations do not seem to show any decided parallax to the object. If its distance were less than half that of the moon, its displacement would be detected in the observations.

Still the query if it may not be an atmospheric phenomenon — some sort of abnormal refraction — is yet a legitimate one, though the absence of parallax is fatal to it.

These observations support and confirm the fact that the '*Gegenschein*' has always a north latitude, as shown by the following:

From 1883 to 1887	$\beta = +0^\circ.4$	16 observations
From 1888 to 1891	$\beta = +1\ .3$	16 "
1893	$\beta = +0\ .5$	22 "

The observations of Professor **Baily**, when published by Prof. E. C. **Pickering**, will doubtless remove any ambiguity in this, and show whether the observed north latitude is not due to atmospheric absorption. If this is shown to be the case, then the lagging of the longitude of the '*Gegenschein*' from $\lambda - \odot = 180^\circ$ will be explained in the same manner.

NOTES.

August 31. A roundish indefinite glow, very hazy. Probably 15° in diameter, but too low to be well seen.

September 1. Roundish, 15° in diameter. No definite boundary or form; only a feeble, but a decided glow.

Sept. 2. Very vague and hazy. At least 20° in diameter. There is possibly a diffusion west, though the *Gegenschein* is essentially round.

Sept. 3. Sky whitish, and *Gegenschein* but faintly seen. It is impossible to tell its extent, but it is roundish. At $11^h\,30^m$, with the nearly half moon some four degrees above the horizon, the *Gegenschein* can still be seen distinctly. The moon is red, and its light has little effect in dulling the *Gegenschein*.

Sept. 8. Very diffused and feeble. Frequent fogging of the sky, and position not good.

Sept. 9. At 14^h it is better seen. It is indefinite and hazy. 15° in diameter.

Sept. 11. Very diluted and diffused. Too difficult to be sure of location. Sky very poor.

Sept. 13. Very diluted and hazy. Possibly extended along the ecliptic. Some 15° in diameter. It seems fainter to-night, though the sky is good. There may be a zodiacal extension west along the ecliptic, but I think there is none to the east. Later, it is better seen. There is a very faint zodiacal band running from the place of *Jupiter* to it. This band is 4° or 5° broad. The *Gegenschein* is too low to show anything to the west of it.

Sept. 15. Dense, hazy and roundish, 15° in diameter. I think there is an extension for 20° east and west. Later, after midnight, it is very large, and is extended along the ecliptic.

Sept. 16. Very diffused, indefinite, hazy and round.

Sept. 18. Dense, and widely diffused. Very large; very indefinite in form, but roundish.

Sept. 20. Very hazy; 15° diameter north and south. There is but little extension to the west — too low? A zodiacal band from it to *Jupiter*.

$15^h\,40^m$, zodiacal light in the east. It is bright — near the middle of the axis it is twice as bright as the Milky Way near *Sirius*. Its axis passes 4° north of γ *Geminorum*, and at the base of the cone on the horizon passes 2° north of *Regulus*, The axis also passes 1° south of δ *Cancri*. Its junction with the Milky Way is distinctly marked.

$16^h\,0^m$, the extreme northern limit of the cone is 2° north of γ *Leonis*.

$16^h\,25^m$, the northern limit is now at γ *Leonis*; ϵ *Leonis* also limits the north edge. The southern edge is better defined; the north edge is very much diffused. The zodiacal light is a very bright object.

Oct. 1. Sky very poor — milky. *Gegenschein* fairly well seen as a large, dense haze; roundish, from 15° to 20° in diameter. It is probably elongated, but it is not possible to be certain of this; I think, however, that there is an elongation along the ecliptic.

Oct. 2. At 11^h it was certainly extended along the ecliptic; no time to observe position.

Oct. 4. Very large and dense. Sky clear. It is 20° in diameter, sensibly elongated. There is a zodiacal band from it east and west. The *Gegenschein* is very dense, and could scarcely be missed by any one looking only casually in its direction.

Oct. 5. Very elongated. No time to observe position.

Oct. 6. Sky whitish. *Gegenschein* is distinctly seen. It is elongated. A zodiacal band runs from it to *Jupiter*. The axis of this band would pass through *Jupiter*. The west part of the zodiacal band is not so distinct.

Oct. 7. Sky poor. The brightest part of the *Gegenschein* is very dense for 6° or 8°.

Oct. 9. Seen through intervals in drifting fog. It is dense. It is so dense as to effect the light of the stars near its center. 20° in diameter, and possibly a little extended, but very dense.

Oct. 11. $13^h\,40^m$, very elongated; 15° × 25°.
$15^h\,0^m$, very elongated.

Oct. 18. It is simply an intensification and swelling of a long zodiacal band. The *Gegenschein* proper is not over 10° in diameter north and south. It stretches along the ecliptic for at least 25°.

In conclusion, I would say that I believe the latitude of the '*Gegenschein*,' and the lagging in longitude, are due to atmospheric absorption, and that this object is exactly opposite the sun, and that it lies in the ecliptic, and if its center were a definite point the position of the sun could be accurately determined from observations of the '*Gegenschein*,' by changing the sign of the declination, and subtracting 12^h from the right-ascension.

Mt. Hamilton, Cal., 1893 *Oct.* 28.

EPHEMERIDES OF LONG-PERIOD VARIABLES FOR 1894,

By S. C. CHANDLER.

The following tables of maxima and minima of variables of long period have been calculated from the elements of the Second Catalogue (*A.J.* 300). Only stars with periods of more than four months are included. Two or three stars have been omitted whose elements are too uncertain to be of service for purposes of prediction.

Instead of adopting a strictly chronological arrangement, the stars whose maxima and minima occur in each month are placed in order of right-ascension. I have found this to be the most convenient form in practice, for making a working list for observation. The line for each star contains its number and name, followed by the day of the month on which its computed phase occurs. A colon is placed against the date, when the elements are noted in the Catalogue as uncertain.

Especial attention is directed to the remarks in the last column of the introduction to the Catalogue.

In the ephemeris of minima, only those stars are included for which data exist in the column $M—m$ of the Catalogue. Our knowledge in this regard is still very defective, although Parkhurst and Townley have done much to ameliorate this condition of affairs. Observers having access to large telescopes, who desire to determine minima of stars for which the Catalogue does not give the interval by which the minima precede the maxima ($M-m$), can find the approximate times, in order to prepare for observation, by interpolating them from the table of maxima; remembering that in most cases the increase is somewhat more rapid than the decrease. For a large proportion of the variables, stars of identification are given in the notes to the Catalogue, which will facilitate the work of finding the variables in their fainter stages. (See *A.J.* VIII, p. 114.)

I take the opportunity to make the following corrections in the Catalogue:

1944 *S Orionis*. Transpose 6 and 11 in the columns M and m, of "Basis of Elements."

1981 *S Camelopardalis*. Strike out period of 111 days.

4847 *S Virginis*. In Julian Epoch of Maximum, *for* 2407512 *read* 2397512.

7560 *R Vulpeculae*. In column $M—m$, *for* 6.20 *read* 62.0.

Also in table in Introduction, equivalent of 1893 Nov. 1, *for* 2765 *read* 2769.

MAXIMA, 1894.

		January
114	*S* Ceti	30
1574	*W* Tauri	8
1582	*S* Tauri	18
1623	*T* Camelopard.	2:
1771	*R* Leporis	10
2100	*U* Orionis	22
2266	*V* Monocerotis	26
2691	*T* Canis min.	22
2742	*S* Geminorum	5
5190	*R* Camelopard.	3
5338	*U* Bootis	12
5795	*W* Scorpii	19
5831	*S* Scorpii	17
5950	*W* Herculis	18
5955	*R* Draconis	27
6682	*X* Ophiuchi	15
6903	*T* Sagittarii	10
7428	*V* Cygni	13
		February
112	*R* Androm.	27
806	*o* Ceti	17
845	*R* Ceti	21
2684	*S* Canis min.	19
2857	*U* Puppis	13:
3060	*U* Cancri	13
6624	*T* Serpentis	27
7659	*T* Capricorni	16
7733	*Y* Capricorni	20:
		March
466	*U* Piscium	16
513	*R* Piscium	23
1717	*V* Tauri	1
2539	*R* Canis min.	3
3994	*S* Leonis	9
4521	*R* Virginis	19
5037	*RR* Virginis	20
5095	*R* Centauri	31
5504	*S* Coronae	26
5583	*X* Librae	21
5593	*W* Librae	12
5688	*R* Librae	28
5856	*W* Ophiuchi	22
5903	*Y* Scorpii	6
6132	*R* Ophiuchi	7
7252	*W* Capricorni	26
7299	*U* Cygni	30
7754	*W* Cygni	24
		April
782	*R* Arietis	10
2583	L_2 Puppis	15
3567	*V* Leonis	11
4596	*U* Virginis	2
5770	*R* Herculis	1
7431	*S* Delphini	9
7455	*U* Capricorni	19
7571	*V* Capricorni	18
		May
107	*T* Cassiopeae	21
906	*R* Trianguli	2
1574	*W* Tauri	29
1577	*R* Tauri	13
1855	*R* Aurigae	28
2013	*U* Aurigae	6:
3170	*S* Hydrae	31
3637	*S* Carinae	3
4847	*S* Virginis	11
5501	*S* Serpentis	18
5887	*V* Ophiuchi	7
6512	*T* Herculis	21
7542	*S* Aquilae	20
7909	*S* Piscis aus.	31
7944	*T* Pegasi	19
		June
2478	*R* Lyncis	22
2625	*V* Geminorum	30
2976	*V* Cancri	17
3493	*R* Leonis	1
4816	*V* Virginis	1
4940	*W* Hydrae	1
5157	*S* Bootis	8
5194	*V* Bootis	23
5249	*V* Librae	26
5494	*S* Librae	19
5644	*Z* Librae	29
5675	*V* Coronae	3
5776	*X* Scorpii	2
5830	*R* Scorpii	30
5889	*U* Herculis	13
6849	*R* Aquilae	6
7045	*R* Cygni	3
7192	*Z* Cygni	12
7577	*X* Capricorni	29
8230	*S* Aquarii	1
8373	*S* Pegasi	25
8600	*R* Cassiopeae	24
		July
243	*U* Cassiopeae	3
494	*R* Sculptoris	14
1222	*R* Persei	2
1582	*S* Tauri	25?
2528	*R* Geminorum	2
4315	*R* Comae	10
4407	*R* Corvi	2
4492	*Y* Virginis	27
5237	*R* Bootis	2
5338	*U* Bootis	4
5704	*RR* Librae	24
5761	*Z* Scorpii	24
5831	*S* Scorpii	13
6905	*R* Sagittarii	2
6921	*S* Sagittarii	6
7261	*R* Delphini	28
8512	*R* Aquarii	4
		August
715	*S* Arietis	8
845	*R* Ceti	7
893	*U* Ceti	18
1717	*V* Tauri	19
2583	L_2 Puppis	30
3184	*T* Hydrae	6
3418	*R* Carinae	9
3477	*R* Leo. min.	31
3825	*R* Ursae Maj.	8
4511	*T* Ursae Maj.	17
4521	*R* Virginis	11
4557	*S* Ursae Maj.	9
5070	*Z* Virginis	5
5430	*T* Librae	14
5438	*Y* Librae	7
5617	*U* Librae	13
5795	*W* Scorpii	29
6044	*S* Herculis	3
7220	*S* Cygni	28
7560	*R* Vulpeculae	7
7609	*T* Cephei	25
7754	*W* Cygni	2
7779	*S* Cephei	16
7907	*U* Aquarii	30:
8153	*R* Lacertae	13
8290	*R* Pegasi	7
8597	*V* Ceti	30
		September
466	*U* Piscium	5
976	*T* Arietis	2
2258	*V* Aurigae	13:
2735	*U* Canis min.	18
2780	*T* Geminorum	7
3637	*S* Carinae	28
3994	*S* Leonis	20
4948	*R* Canis Ven.	30
5190	*R* Camelop.	30
5583	*X* Librae	11
5955	*R* Draconis	29

	September	
7444	*T* Delphini	9
7468	*T* Aquarii	16
7571	*V* Capricorni	22
7733	*Y* Capricorni	14 :
	October	
782	*R* Arietis	13
1574	*W* Tauri	17
1635	*R* Reticuli	5
1761	*R* Orionis	4
2742	*S* Geminorum	26
3890	*W* Leonis	14
4377	*T* Virginis	11
4596	*U* Virginis	26
5593	*W* Librae	4
5677	*R* Serpentis	20
5950	*W* Herculis	24
7242	*S* Aquilae	13
7252	*W* Capricorni	21
	November	
432	*S* Cassiopeae	6
434	*S* Piscium	11
1944	*S* Orionis	26
2946	*R* Cancri	20
5928	*T* Ophiuchi	9 :
5931	*S* Ophiuchi	22
6512	*T* Herculis	2
7234	*R* Capricorni	23 :
7455	*U* Capricorni	8
7659	*T* Capricorni	13
	December	
114	S Ceti	17
2266	*V* Monocerotis	15
2691	*T* Canis min.	11
2857	*U* Puppis	25:
3060	*U* Cancri	12
4826	*R* Hydrae	30
5338	*U* Bootis	25
5494	*S* Librae	28
5776	*X* Scorpii	8
7120	χ Cygni	4
7560	*R* Vulpeculae	23
7754	*W* Cygni	11

Minima, 1894.

	January	
432	*S* Cassiopeae	10 :
513	*R* Piscium	5
782	*R* Arietis	9
906	*R* Trianguli	3
2478	*R* Lyncis	30
3493	*R* Leonis	8
4521	*R* Virginis	10
4596	*U* Virginis	4
5095	*R* Centauri	30 :
5157	*S* Bootis	29
5583	*X* Librae	0
6849	*R* Aquilae	13
6905	*R* Sagittarii	25 :
7045	*R* Cygni	4
7560	*R* Vulpeculae	19
7754	*W* Cygni	10
8600	*R* Cassiopeae	5
	February	
715	*S* Arietis	24 :
2583	L_2 Puppis	14
2625	*V* Geminorum	16
3637	*S* Carinae	6
6512	*T* Herculis	24
7192	*Z* Cygni	7 :
7609	*T* Cephei	13
8290	*R* Pegasi	16 :
	March	
243	*U* Cassiopeae	5
494	*R* Sculptoris	5 :
1222	*R* Persei	28
1574	*W* Tauri	12
1761	*R* Orionis	4 :
2528	*R* Geminorum	2
2735	*U* Canis min.	27
2976	*V* Cancri	7 :
3418	*R* Carinae	9
3477	*R* Leonis min.	14
5194	*V* Bootis	18
5237	*R* Bootis	22
5494	*S* Librae	11 :
6044	*S* Herculis	8
6921	*S* Sagittarii	18 :
7242	*S* Aquilae	9
7577	*X* Capricorni	5
	April	
434	*S* Piscium	25 :
976	*T* Arietis	28
3825	*R* Ursae Maj.	23
4557	*S* Ursae Maj.	18
5338	*U* Bootis	15
5795	*W* Scorpii	5 :
7220	*S* Cygni	6 :
	May	
845	*R* Ceti	29
1582	*S* Tauri	16 ?
1717	*V* Tauri	22
1944	*S* Orionis	16
2213	η Geminorum	10
3994	*S* Leonis	18 :
4492	*Y* Virginis	3 :
4511	*T* Ursae Maj.	1
5190	*R* Camelop.	18
5430	*T* Librae	1
5677	*R* Serpentis	22
7754	*W* Cygni	21
	June	
466	*U* Piscium	14
2742	*S* Geminorum	21 :
4521	*R* Virginis	4
4826	*R* Hydrae	23
5583	*X* Librae	13
5950	*W* Herculis	21
5955	*R* Draconis	9
6682	*X* Ophiuchi	22
7120	χ Cygni	15
7468	*T* Aquarii	20
7560	*R* Vulpeculae	6
7659	*T* Capricorni	29 :
	July	
114	*S* Ceti	25
782	*R* Arietis	14
1574	*W* Tauri	31
2583	L_2 Puppis	1
2946	*R* Cancri	18 :
3637	*S* Carinae	4
4596	*U* Virginis	30
5095	*R* Centauri	9 :
7252	*W* Capricorni	26 :
7428	*V* Cygni	30
	August	
1771	*R* Leporis	22
2684	*S* Canis min.	4
6512	*T* Herculis	8
7242	*S* Aquilae	2
	September	
494	*R* Sculptoris	28 :
806	*o* Ceti	23
906	*R* Trianguli	22
2100	*U* Orionis	5 :
2539	*R* Canis min.	21
5494	*S* Librae	20 :
7431	*S* Delphini	16
7754	*W* Cygni	29
	October	
112	*R* Androm.	25 :
1222	*R* Persei	22
4521	*R* Virginis	27
5157	*S* Bootis	24
5338	*U* Bootis	7
6905	*R* Sagittarii	20 :
7192	*Z* Cygni	30 :
7560	*R* Vulpeculae	22
7577	*X* Capricorni	10
	November	
845	*R* Ceti	12
1577	*R* Tauri	14 :
1582	*S* Tauri	19 :
1717	*V* Tauri	8
2583	L_2 Puppis	14
2625	*V* Geminorum	20
3493	*R* Leonis	18
3637	*S* Carinae	30
3994	*S* Leonis	28 :
4557	*S* Ursae Maj.	27
5194	*V* Bootis	29
5237	*R* Bootis	2
5504	*S* Coronae	26
5795	*W* Scorpii	13 :
6921	*S* Sagittarii	4 :
7299	*U* Cygni	19
	December	
107	*T* Cassiopeae	31
243	*U* Cassiopeae	6
466	*U* Piscium	3
715	*S* Arietis	13 :
1574	*W* Tauri	19
2213	η Geminorum	27
2976	*V* Cancri	4 :
4492	*Y* Virginis	8 :
4847	*S* Virginis	15 :
5095	*R* Centauri	17 :
5430	*T* Librae	25
5583	*X* Librae	3
5675	*V* Coronae	5
6849	*R* Aquilae	2
7242	*S* Aquilae	27

OBSERVATIONS OF COMET *c* 1893 (*BROOKS*),

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

1893 Cincinnati M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Nov. 4 15 55 59	1	12	−0 46.09	−1 20.2	12 50 7.99	+26 34 27.6	*n*9.710	0.690
6 16 17 48	2	10	+0 36.28	+1 19.3	12 53 52.22	+28 15 18.6	*n*9.712	0.619
8 16 31 34	5	6	−4 48.49	−1 53.4	12 57 46.54	+29 58 58.2	*n*9.713	0.611
16 31 34	6	6	−5 46.04	+1 55.1	12 57 46.12	+29 59 3.5	*n*9.713	0.611
14 15 35 30	7	8	+2 48.76	+0 59.6	13 10 41.03	+35 27 57.9	*n*9.750	0.650
18 15 28 1	8	4	+3 56.46	−0 3.2	13 20 41.12	+39 26 3.9	*n*9.773	0.629
15 28 1	9	8	+0 18.75	−2 26.8	13 20 41.52	+39 26 2.7	*n*9.773	0.629
21 17 12 14	10	12	+2 41.62	−0 16.3	13 29 20.20	+42 38 13.4	*n*9.743	0.289

Mean Places for 1893.0 of Comparison-Stars.

*	α (h m s)	Red. to app. place (s)	δ (° ′ ″)	Red. to app. place (″)	Authority
1	12 50 52.92	+1.16	+26 36 3.2	—15.4	Bessel Weisse XII, 989, 90
2	12 53 14.77		+28 14 15.5		Equatorial comparison with
3	12 51 40.63	+1.17	+28 23 13.3	—16.2	Bessel Weisse XII, 1002, and
4	12 53 32.05		+28 3 26.8		Bessel Weisse XII, 1030
5	13 2 33.89	+1.11	+30 1 8.6	—17.0	Leiden A.G.Z. ; 4 obs.
6	13 3 31.02	+1.14	+29 57 25.4	—17.0	Leiden A.G.Z. ; 2 obs.
7	13 7 51.06	+1.21	+35 27 18.4	—20.1	Bonn VI, 35°2422, and Lund. A.G.Z. ; 2 obs.
8	13 16 43.48	+1.18	+39 26 29.1	—22.0	Lund. A.G.Z. ; 2 obs.
9	13 20 21.62	+1.15	+39 28 51.4	—21.9	Lund. A.G.Z. ; 2 obs. [2101
10	13 26 37.47	+1.11	+42 39 22.9	—23.2	Pulk. 2016, Yar. 5690, Brux. 5492, Gr. 10-Yr.

ELEMENTS AND EPHEMERIS OF COMET *c* 1893 (*BROOKS*),

BY PHILLIPS ISHAM AND J. G. PORTER.

The elements of Comet *c*, which were published in no. 307 of the *A.J.*, prove to be faulty, owing to a mistake of a minute in one of the latitudes, not discovered until too late. As better data were then available, Mr. ISHAM and myself computed a new orbit from observations at Hamburg, Oct. 17, and Cincinnati, Oct. 30 and Nov. 14.

The deviation of the middle place is

$$(\text{C—O})\quad \Delta\lambda \cos\beta\ -7''.5, \quad \Delta\beta\ +3''.0.$$

$$T = 1893 \text{ Sept. } 19.3055 \text{ Berlin M.T.}$$

$$\left.\begin{aligned} \Omega &= 174^\circ\ 54'\ 21'' \\ i &= 129\ \ 47\ \ 44 \\ \omega &= 347\ \ 33\ \ 10 \end{aligned}\right\}\ 1893.0$$

$$\log q = 9.91033$$

EPHEMERIS FOR BERLIN MIDNIGHT.

1893 Dec.	App. α (h m s)	App. δ (° ′)	log Δ	Br.
1.5	14 3 53	+53 15.1	0.119	0.67
2.5	8 27	54 23.9		
3.5	13 15	55 32.7		
4.5	18 21	56 41.4	0.118	0.64
5.5	23 44	57 50.0		
6.5	14 29 25	+58 58.4		
7.5	14 35 25	+60 6.2	0.117	0.60
8.5	41 48	61 13.2		
9.5	48 35	62 19.4		
10.5	14 55 50	63 24.8	0.119	0.57
11.5	15 3 33	64 28.7		
12.5	11 48	65 31.0		
13.5	20 36	66 32.1	0.123	0.53
14.5	29 59	67 31.7		
15.5	40 3	68 29.0		
16.5	15 50 52	69 23.4	0.129	0.50
17.5	16 2 26	70 15.3		
18.5	14 47	71 4.4		
19.5	27 57	71 50.2	0.136	0.46
20.5	41 59	72 32.4		
21.5	16 56 50	73 10.7		
22.5	17 12 30	73 45.0	0.145	0.42
23.5	28 57	74 14.9		
24.5	17 46 6	74 40.2		
25.5	18 3 41	75 0.6	0.156	0.38
26.5	21 34	75 16.1		
27.5	39 40	75 26.6		
28.5	18 57 53	75 32.5	0.168	0.35
29.5	19 15 52	75 33.8		
30.5	33 28	75 30.7		
31.5	19 50 33	+75 23.3	0.181	0.31

ANNOUNCEMENT REGARDING VARIABILITY OF TWO STARS.

Rev. Mr. ESPIN announces, under date of Nov. 14, that an anonymous red star, situated $19^h\ 7^m\ 16^s$, $+25^\circ\ 46'$ (Eq. 1855.0), and observed by him Aug. 21 as $9^M.0$, had diminished to 11^M. Also that he had photographically confirmed the variation of a red star, in $19^h\ 59^m\ 6^s$, $+36^\circ\ 25'$, previously announced by him. No details are given.

NEW ASTEROID.

Prof. KREUTZ has communicated the discovery of another asteroid by Prof. MAX WOLF, at Heidelberg, upon his photographic plates:

1893 *AO* 13^M Nov. 6 $9^h\ 18^m$ Heidelberg M.T. $\alpha = 2^h\ 19^m.5$, $\delta = +11^\circ\ 22'$. Daily motion, -36^s in α, and $2'$ southward.

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ANNOUNCEMENT REGARDING VARIABILITY OF TWO STARS.
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OBSERVATIONS OF SUSPECTED VARIABLES,

BY PAUL S. YENDELL.

(691) — *Persei*.

Since the observations published in No. 279 of this Journal, I have looked for this star frequently, without finding anything so bright as 11^{M} in its place; I have recorded observations on the following dates:

1892 Oct. 23	1893 Jan. 20
29	Feb. 4
Nov. 8	Mar. 7
11	18
20	Apr. 5
24	Oct. 29
Dec. 7	Nov. 10
9	

(1279) — *Camelopardalis*.

Since publishing the observations of this star in this Journal, No. 279, I have secured the following additional ones:

	M		M
1892 Oct. 22	8.6	1893 Oct. 9	8.7
29	8.6	14	8.7
Dec. 16	8.8	18	8.7
1893 Apr. 4	8.4:	Nov. 4	8.7
Sept. 13	8.8	7	8.8
16	8.7		

There remains no doubt in my mind that the star is absolutely constant. It is very red, two absorption-estimates agreeing at 8.0 of CHANDLER's scale.

(2170) — *Leporis*.

A recent observation of this star, taken in connection with those secured in January and February of this year, fully confirms its variability.

Particulars will be furnished in a future number.

(6943) — *Sagittae*.

I published, in No. 292 of this Journal, a few observations of this star, made in the summer of 1892; for the present season, I have, up to this date, the following observations, which I consider to place the star's variation beyond a doubt.

	M		M
1893 Aug. 29	8.9	1893 Oct. 14	9.2
Sept. 2	8.6	18	9.1
8	8.6	21	9.1
9	8.9	31	9.1
Oct. 6	9.0	Nov. 1	9.2
9	9.0	11	9.3
11	9.0	16	9.3

A maximum is indicated on Sept. 4, and a comparison of the two seasons' observations suggests that star's period may be rather more than a year.

Birmingham 558.

$\alpha = 20^{h}\ 18^{m}\ 45^{s}.1, \qquad \delta = +9^{\circ}\ 36'.0\ (1855).$

BIRMINGHAM says "this star is certainly variable," and quotes ARGELANDER in support of the statement. I have observations as follows:

	M		
1892 Aug. 13	7.3	1893 Sept. 13	7.3
16	7.3	Oct. 21	7.0
21	7.3		
29	7.4		
Sept. 10	7.4		

Its color is not conspicuous, a single observation showing very uncertainly 4.0 of redness.

Its constancy during the period covered by the observations seems beyond a doubt.

(7351) — *Cygni*.

I have the following observations of this star:

	M		M
1892 Nov. 19	9.2	1893 May 11	8.9
22	8.9	June 10	9.1
Dec. 2	8.6	18	9.1
5	8.6	28	8.9
7	9.1	July 4	9.0
9	8.3	14	9.0
11	8.9	23	9.0
16	8.3	Aug. 29	9.3
22	8.3	Oct. 18	9.4
26	8.3	Nov. 7	9.5
29	8.3	16	9.5

At the end of the season of 1892, I considered my observations, although showing an apparent rise from $9^{M}.2$ to $8^{M}.3$, rather indecisive, in view of the star's strong orange color, seven observations showing a redness of 7.0, but the discordance between the estimates of December 1892 and those of November 1893 is too great to be attributed to the color, the star being at the former dates conspicuous in my telescope, and at present quite faint.

I consider the star to be certainly variable.

SDM. —4° 5257.

$\alpha = 20^{h}\ 39^{m}\ 9^{s}.5, \qquad \delta = -4^{\circ}\ 35'.1$ (1855).

The variability of a star, assumed to be identical with this, is announced from the Harvard College Observatory (*Astronomische Nachrichten*, 3025); photographic magnitudes of $8^{M}.6$, $8^{M}.6$, $8^{M}.4$, $9^{M}.1$, $9^{M}.6$ being given.

I have observations as follows:

	M		M
1893 July 21	8.1	1893 Sept. 13	8.2
Aug. 30	8.2	Oct. 14	8.1
Sept. 9	8.1	21	8.1

The star is but slightly colored, three observations giving 3.8 of redness. During the four months that I have had it under observation, it has certainly been constant.

Its place was published in an announcement, from the Harvard College Observatory, of photographically discovered variables, in the *Astr. Nachr.*, No. 3025, p. 5, as follows, R.A., $20^{h}\ 41^{m}.3$, Decl. —4° 26′ (1900). This place, when reduced to the equinox of 1855, so nearly coincided with the place of this SDM. star, as to make its identity therewith a fair assumption, and the star was accordingly taken under observation.

After the above observations were in type, it came to my knowledge that in a later volume of the *Nachrichten* there had been published a correction to the place given in the original announcement, the corrected α being $20^{h}\ 43^{m}.1$, a difference of $1^{m}.8$ from the first-published place.

In this connection, I beg to make a remark with reference to the criticism in "*Astronomy and Astrophysics*," No. 118, p. 687. It is often exceedingly difficult, even for an observer who tries to be careful, to recognize the correct star, on account of the inaccuracy of the positions given by those who announce variability. Different positions have repeatedly been given for the same stars in the announcements made by the Harvard College Observatory. Thus they have given places differing by 12^{s} in α, and $11'$ in δ, for (1018)—*Horologii*; by $3^{m}\ 12^{s}$ in α, and $4'$ in δ, for (2141)— *Octantis*; by 12^{s} in α, and $5'$ in δ, for (5174)—*Virginis*; by $4^{m}\ 6^{s}$ in α, and $1'$ in δ, for (6275)— *Octantis*; by 6^{s} in α, and $1'$ in δ, for (7139)—*Sagittarii*; by $1^{m}\ 0^{s}$ in α, for (8594)—*Tucanae*; besides the one first quoted, by which I was misled into observing and publishing observations of the wrong star.

And in this case only was the change noted as a correction of a previous announcement. The difficulty is increased by the fact that in all the other cases the places were published in different periodicals at different times, nothing being said to call attention to the previous errors of announcement.

In view of these facts, the remarks above referred to hardly seem justified. If merely ordinary care is exercised by those who announce cases of variability, I apprehend there will be no danger of errors of identification by those who busy themselves with the verification of announced variables.

(7450) — *Aquarii.*

The variability of this star was announced by DE BALL (*Astronomische Nachrichten* 3116), with full details of comparison-stars, and numerous estimates of observed magnitudes, from which he deduces two maxima, 1891 Jan. 4 ± and Oct. 4–5, and two minima, 1890 Sept. 16? and 1891 Dec. 24?

My observations from 1893 July 16 to Nov. 9, eighteen in number, fully confirm the star's variability. Beginning at the former date with a magnitude of 9.1, they show a steady increase to $8^{M}.1$ on Sept. 11, and $8^{M}.2$ on Oct. 5, and a rapid decline to $9^{M}.3$, which was the magnitude last observed, Nov. 9.

A maximum is indicated Sept. 22 ±. Taking this in connection with DE BALL's maxima, above quoted, a period of about eight months appears possible.

In the magnitude-estimates here given of my own observations, I have used the Albany values, as more accordant with the light-scale formed from my own comparisons than are those given by DE BALL.

A single color-observation gives 2.5 of redness.

(7458) — *Delphini.*

I have looked for this star sixteen times during this season, from 1893 Aug. 15 to Nov. 18. It was first seen, and estimated at $11^{M}.5$ on Nov. 7, since which it has increased rapidly, two regular comparisons having been made on Nov. 16 and 18, on both of which occasions it was estimated at $10^{M}.0$, being well seen during bright moonlight at the last observation.

The star is certainly variable.

(8499) — *Aquarii.*

In view of the doubt as to the identity of this star, I have mostly used the method of sequences in observing it; from my observations, twelve in number, extending from 1893 July 6 to Nov. 1, the interval between 103 and 104 appears to be constant, the observed difference varying more than a single step from its mean value in only one instance.

(8617) — *Cassiopeae.*

Between 1891 Sept. 2 and 1893 Nov. 7, I have eighteen observations of this star. In spite of its redness (two observations showing 8.6) the estimates are very accordant, showing an average deviation of only $0^{M}.1$ from their mean, which is $8^{M}.0$, and in but two instances departing from this mean more than $0^{M}.2$.

I have also five estimates of its blue neighbor, which BIRMINGHAM asserts to be also variable, 9^{M}–10^{M}, but of which I have but one estimate other than $9^{M}.0$.

Both stars are undoubtedly constant.

Dorchester, 1893 *Nov.* 19.

The above confirmation by Mr. Yendell of the variability of five stars of the unconfirmed list (*A.J.* 300, p. 109), permits their definitive notation to be assigned as below. The other data, corresponding to the left-hand page of the Catalogue, have also been supplied by Dr. Chandler. — Ed.

No.	Star	1900.0 R.A.	1900.0 Decl.	1900 Annual Variation		1855.0 R.A.	1855.0 Decl.	Redness	Magnitude Max.	Magnitude Min.
		h m s	° ′	s	′	h m s	° ′			
2170	*S Leporis*	6 1 38	—24 11.2	+2.47	+0.00	5 59 47	—24 11.1	–	6.7	7.5
6945	*T Sagittae*	19 17 14	+17 28.1	2.68	0.11	19 15 13	+17 23.2	–	8.3	9.9
7351	*R W Cygni*	20 25 12	+39 38.8	2.18	0.20	20 23 34	+39 23.9	7.0*	7.7	9.5
7450	*V Aquarii*	20 41 46	+ 2 4.2	3.04	0.22	20 39 29	+ 1 54.6	2.5*	8.1	9.3
7458	*V Delphini*	20 43 13	+18 58	+2.72	+0.22	20 41 10	+18 48	–	9 ?	12 ?

RESEARCHES UPON COMET 1889 V,

By CHARLES LANE POOR.

III.

The following paper embodies some of the results of an investigation upon the path of this remarkable body, whilst it was in the immediate vicinity of *Jupiter*. And the first question which naturally presented itself, was whether there had been any close approach to one or more of the satellites.

The solar perturbations were integrated and applied to the hyperbolic elements of the comet, and thus were derived the elements of the hyperbola, in which the comet was traveling on the day of closest approach to *Jupiter*, namely:

$$\begin{array}{rcll}
\pi & = & 282^\circ\ 44'\ \ 8'' & +249''.59\,r \\
\Omega & = & 251\ \ 18\ \ \ 4 & -\ 14\ .21 \\
i & = & 61\ \ 41\ \ 50 & -120\ .66 \\
a & = & -0.083\,304\,3 & -0.000\,010\,274\,r \\
e & = & +1.012\,739\,8 & +0.000\,179\,192\,r \\
T & = & \text{July}\,20.10452 & -0.081\,353\,r
\end{array}$$

Thus, the plane of the comet's orbit cut that in which the satellites move at a large angle, and further, the difference of longitudes of the peri-jove and the ascending node was only about 28°. Thus, at the ascending node the comet crossed the line of nodes at a large angle; while near the descending node the path of the comet was for a time nearly parallel with the line of nodes. Hence, as the comet neared *Jupiter* there could be no close approach to any of the satellites, excepting very near the node. But, on the other hand, as the comet receded from the planet, it hovered over the satellites, and close approaches might occur at considerable distances from the descending node.

During the entire time, however, that the comet was in the vicinity of *Jupiter* and the satellites, it was moving so rapidly that nothing except a very close approach could have any appreciable influence. Indeed, to have caused any noticeable alteration in the relative orbit about *Jupiter*, the comet must have passed within the "sphere" of the disturbing satellite. Now the distances of the satellites, and the radii of these various "spheres of attraction," taken in reference to *Jupiter*, are exhibited in the table below, where the unit of distance is the semi-diameter of *Jupiter*.

	Distance	Sphere
Satellite I	5.93	0.0647
" II	9.44	0.1175
" III	15.06	0.3199
" IV	26.49	0.4196

These values were obtained from the masses and distances, as given by Newcomb.

The following table shows at a glance the character of the approach to each of the four satellites for the different values of r.

Approach to Satellites.

r	℧	☊	Closest approach to orbit I	II	III	IV	Differences of longitude. Comet —Satell. I	II	III	IV
							°	°	°	°
—40	21.93	1.06	4.87	1.83	1.09	1.02	— 24.1	+ 34.0	— 92.1	—140.0
—20	33.00	1.75	4.18	3.21	2.69	1.07	— 53.0	—165.2	— 13.6	—107.3
0	41.93	2.13	3.50	4.12	4.32	2.65	— 80.4	— 2.0	+ 70.7	— 77.5
+20	48.43	3.14	2.79	5.12	5.03	3.95	—108.2	+156.4	+155.0	— 40.9
+40	55.45	3.83	2.10	5.46	5.94	5.02	—134.9	— 40.5	—135.3	— 7.8

The first two columns give the respective distances of the nodes from the center of *Jupiter*, the equatorial radius of the planet being taken as unity. The following four columns give the smallest possible distances between the orbits of the various satellites and that of the comet for the different values of r; the remaining columns give the differences of longitude of the comet and satellites at the moment when the comet passed the point of closest approach to the orbits of the satellites.

Thus we see that there was no approach near enough to cause the slightest change in the relative orbit of the nucleus about *Jupiter*. In no possible case did the nucleus approach a satellite nearer than forty (40) times the radius of its "sphere of control;" at this distance the perturbations by the satellite would be entirely inappreciable.

Again, as to the disruption of the comet. The above table shows, I think, pretty clearly, that this could not have been caused by the action of any one of the four outer satellites. For the radius of the comet, although a very uncertain quantity, could hardly have been larger than that of *Jupiter*; and was probably not more than one-half that amount. Now, even taking the greater of these two quantities, we see that in no possible case did any of the cometary matter pass within the "sphere" of a satellite, and hence there could have been no disruption due to this cause.

In all that goes before, I have left entirely out of consideration the Fifth Satellite. If this body were in existence in 1886, there is great probability that it passed directly through the comet; for, upon the hypothesis of $r = 0$, the distance of the node was only 2.5, while the mean distance of the satellite is only about 2.6, and hence if the satellite had been in that part of its orbit at the time the comet passed its node, a collision must certainly have taken place. Again, for all values of r between ± 20, the nodal distance is found to lie between the limits of 3.13 and 1.75, and within these limits it was possible for some part of the comet to touch the satellite. But for each of these different values of r the comet would arrive at its node at widely different times, covering a total period of 3.245 days, so that it would be impossible to say in general that a collision did or did not take place; each possible case would have to be investigated separately. Again, there is still a slight uncertainty in the period of the satellite, which of itself renders vain all attempts at definite statements. It is, therefore, possible that the observed disruption of the comet was caused by the action of this satellite. But, all things considered, it is more probable, I think, that it was caused by the action of *Jupiter* itself, and in another paper I hope to treat of this view of the matter at some length.

Another interesting question that arose, was whether there had been any large disturbances in the motion of the nucleus due to *Jupiter's* ellipticity. The very close approach to the surface of the planet indicated such perturbations, and the asymmetric position of the orbit allowed of but little balancing of effects on the comet's approach and recession. Our present knowledge of the orbit about *Jupiter* is, however, so uncertain, that a rigorous treatment of this question is useless, if not impossible. All that I hoped for in the present investigation, was to obtain some idea as to the possible amount of the disturbance, to determine whether or no it might be neglected in the definitive solution some years hence.

For this purpose I used the mean hyperbola, already given, taking no account of the indeterminate, r, and computed the special perturbations due to the ring of equatorial matter, using the method of variation of constants. The quantities of which the perturbations were found are as follows: the four elements, π, Ω, i and e, and the two auxiliary quantities, r and N, (WATSON's notation). The necessary formulas for computing the differential coefficients of these quantities had already been derived for the work on solar perturbations. The formulas for computing the disturbing forces, R, S and W, were found as follows:

LAPLACE in the *Mécanique Céleste* expresses that part of the perturbative function, which depends upon the ellipticity of *Jupiter*, in the following form,

$$\tfrac{1}{3}(\rho-\tfrac{1}{2}\phi)(1-3\sin^2\delta)\frac{MB^2}{r^2}$$

where the factor $(\rho-\frac{1}{2}\phi)$ depends upon the shape and the speed of rotation of the planet; B is the equatorial radius of *Jupiter*, and r and δ are respectively the radius vector and jovian declination of the disturbed body. From investigations on the motions of the satellites the value of the first factor was found by LAPLACE to be,

$$\log(\rho-\tfrac{1}{2}\phi) = 8.34047$$

From these we readily find by differentiation the expressions for the disturbing forces in the directions of r and δ; and thence by resolving the latter into its components, the required forces, R, S and W. The formulas for this latter step are rather complicated, unless we first refer the elements of the comet's orbit to *Jupiter's* equator as the fundamental plane, or else neglect the inclination of this latter to the ecliptic. This we may do for a first approximation, without introducing any great error; for this inclination is but 3°, whilst the orbit of the comet was inclined about 61°. The disturbing forces thus derived were found to be, at the time of closest approach, as great as one per cent. of the central controlling force of *Jupiter*.

With the formulas thus derived I computed the perturbations during two days of closest approach, using at first an interval of an hour, but found it necessary to reduce this to fifteen minute intervals for the six hours on each side of peri-jovian passage. The numerical results apply only to the mean hyperbola, $r = 0$; and the integrated values of the perturbations are as follows, the osculating curve being that of July 22.5,

$$\begin{aligned}
\Delta\pi &= +11'\ 11''\\
\Delta\Omega &= +11\ \ 45\\
\Delta i &= -\ 0\ \ 34\\
\Delta e &= -0.000\,0654\\
\Delta r &= -0.000\,0816\\
\Delta N &= -0.000\,1272
\end{aligned}$$

For the hyperbolas corresponding to different values of r, the results would differ greatly from the above; for the disturbing forces are proportional to the inverse fourth power of r. For large positive values of the indeterminate, r, the perturbations would be almost inappreciable; for large negative values, on the other hand, the comet approaches so near the surface of the planet that the perturbations would be increased many fold.

The above perturbations were applied, and the resulting hyperbolic elements carried back to March 24.5 by applying the solar perturbations for the interval, with the following result for the osculating hyperbola about *Jupiter* on that date.

$$\pi = 284° \; 24' \; 50''$$
$$\Omega = 256 \;\; 20 \;\; 43$$
$$i = 63 \;\; 41 \;\; 51$$
$$F = 77 \;\; 34 \;\; 30.6$$
$$\log a = 8.949\,273\,6$$
$$\log e = 0.004\,892\,2$$
$$\log r = 7.939\,299\,6$$

At this date the motion of the comet was referred back to the sun, the transformation being performed in the usual manner. In order to show more directly the effect of the disturbance caused by *Jupiter's* ellipticity, I have placed side by side in the following table, the values of the heliocentric coordinates and velocities, derived by neglecting, and by taking account of, these perturbations. The logarithms of the actual numbers are given, and the values of the undisturbed quantities are taken direct from the table in *A.J.* no. 303.

HELIOCENTRIC COORDINATES AND VELOCITIES OF THE COMET 1886 MARCH 24.5.

	Undisturbed	Disturbed
$x =$	$n0.738\,433\,0$	$n0.738\,500\,2$
$y =$	$9.159\,833\,9$	$9.158\,870\,5$
$z =$	$n8.789\,564\,9$	$n8.787\,360\,8$
$dx =$	$6.385\,475\,0$	$6.395\,388\,8$
$dy =$	$n7.956\,797\,6$	$n7.956\,641\,0$
$dz =$	$7.085\,161\,7$	$7.084\,042\,9$

From these were derived the elliptic elements which represent the orbit that the comet was describing about the sun on 1886 March 24.5. I again place the results in parallel columns with those derived in my paper in *A.J.*, no. 303, where this action was neglected.

ELLIPTIC ELEMENTS OF THE COMET,
Epoch, 1886 March 24.5

	Undisturbed	Disturbed
$\pi =$	187° 14′ 0″.7	187° 20′ 11″.7
$\Omega =$	183 17 16 .8	183 16 34 .4
$i =$	7 39 17 .6	7 38 16 .2
$\omega =$	3 56 43 .9	4 3 37 .3
$\log a =$	1.081 266 8	1.080 427 5
$\log e =$	9.738 451 6	9.737 734 4
$\log \mu =$	1.928 106 4	1.929 365 3
$T =$	June 24.0752	June 25.1046

The corresponding periods are respectively 41.8698 and 41.7486 Julian years. We thus see that the disturbing effect of the planet's ellipticity changes this important element by a little over a tenth of a year. Thus, while the disturbance is large enough to sensibly affect our final conclusions in regard to the identity of this comet with that of Lexell, yet it is not sufficient to change materially the present aspect of the problem as outlined in *A.J.*, no. 303. It was there pointed out that there is bound to be at present an uncertainty of fully two years in the period of the comet before 1884, and that this uncertainty was due to the original observations. Now the results of the present investigation merely indicate that this limit of uncertainty is not quite broad enough: that the periods there assigned to the comet for large negative values of the unknown, r, may be in error by a considerable amount. And should the final elements of the comet derived from its next appearance correspond to a small positive, or to any negative value of r, then must these perturbations be most carefully computed.

NOVEMBER 1893 METEOR NOTES,

BY EDWIN F. SAWYER.

Short watches, aggregating 1.5 hours, were taken on the mornings of the 14, 15, 16 and 17 November, the 12 and 13 being overcast, for possible signs of the returning *Leonid* meteor shower due in 1899, but the almost entire absence of these meteors this year, shows that the forerunners of this stream have not as yet been encountered, but should be looked for at each yearly passage of the earth through the cometary meteor path. Of nine meteors observed, only two could be traced to the *Leonid* stream, one each on the 16 and 17. The **BIELA** meteors were looked for on the 25, 26, 28, 29 and 30, the 27 being overcast, but none were observed.

On Nov. 30, at $5^h\,43^m$, Boston M.T., a brilliant meteor was observed slowly passing through *Pegasus* towards the southeast, where it faded away near the horizon. When first seen, it was about equal to a first-magnitude star and of a whitish color. As it slowly descended in a nearly vertical line, it gradually grew in size until, just before disappearance, it was considerably more brilliant than *Venus*, and of a rich emerald green color. The meteor threw off many sparks in its passage, and its brilliancy, by obscuring the stars near its track, prevented its exact path being located; but a careful inspection of the region through which it passed allowed its course to be fairly well determined, which was from about R.A. 350°, and Decl. 12° N., to R.A. 28°, Decl. 20° S. It was visible for about four seconds, and was, among many thousands of meteors observed by the writer, one of the most brilliant recorded.

Brighton, 1893 *Dec.* 2.

OBSERVATIONS OF *Y SAGITTARII*,

By Lieut.-Col. E. E. Markwick.

I have obtained observations of 6573 *Y Sagittarii* on 47 days this season, and beg to forward the same to the *Astronomical Journal*, together with a comparison between observation and calculation. The observations were made with a binocular field-glass, magnifying about five times, and comprise seventeen epochs. The star was compared with No. 45 of the *Uran. Argent.* in *Sagittarius* ($6^{M}.5$), and the difference estimated in steps or tenths of a magnitude. When in England or Ireland I was able to get comparatively few observations, but in this latitude (36° 7′ N.) the altitude of the star is such as to give opportunities for a good series of observations.

According to my eye, *Y Sagittarii* varies between 5.7 and 7.0 magnitudes of the *U. A.* scale. A curve was drawn on tracing paper representing the light changes from maximum to maximum, using these limits of brightness, and the period of 5.7732 days given on p. 11 of Dr. S. C. Chandler's Second Catalogue of Variable Stars. The quantity (*M—m*) was also taken thence, viz.: 1.80 days. Paper was prepared on the same scale, and the observations plotted down, also the maxima, calculated from the data in the same catalogue. The curve was then applied for each epoch, and the differences C—O read off with a boxwood scale as nearly as possible.

The result of this scrutiny is to confirm the period of 5.7732 days. Several maxima fall almost exactly on, or very close to, the calculated positions. Also, I do not see that the interval (*M—m*) could be improved upon. In several cases divergencies from the typical curve are accounted for by the effect of moonlight. The sum of the 22 positive differences is 9.7, that of the 19 negative 9.0, which would seem to indicate they are due to errors of observation. Plotting the whole of the 50 observations on the typical curve, they seem to the eye to cluster very fairly round it, especially near maximum, and I conclude they confirm the data given in the catalogue referred to.

Date, G.M.T.	Mag.	C—O	Date, G.M.T.	Mag.	C—O
1893 h m		d	1893 h m		d
July 6 10 6	5.8	0.0	Sept. 1 9 35	6.7	0.0
7 9 56	5.8	+0.2	3 10 14	6.0	—0.2
8 9 51	6.0	+0.5	5 9 29	6.8	+0.1
11 10 16	6.6	—0.1	9 8 39	6.3	—0.7
12 10 (?)	5.6	—0.1	10 8 1	6.4	+0.1
14 10 26	6.1	+0.6	11 7 36	6.5	+0.9
19 10 41	5.8	—0.1	11 9 6	6.7	+0.6
20 11 30	6.1	+0.1	12 9 12	7.0	0.0
22 9 1	6.2	—1.5	13 9 12	6.6	+0.4
29 8 37	5.9	—0.1	15 9 56	6.3	—0.4
31 11 45	6.2	0.0	19 8 51	6.6	+0.6
Aug. 3 11 6	6.5	—0.2	20 7 41	6.5	+1.5
4 9 1	5.8	+0.1	23 8 31	7.0	—0.3
4 10 6	5.9	+0.4	25 8 36	5.75	0.0
5 9 28	5.9	0.0	29 8 53	6.9	—0.5
10 10 51	6.2	+0.9	30 7 21	6.9	+0.4
11 8 48	6.05	—0.3	30 8 50	7.0	+0.8
12 8 46	6.2	+0.4	Oct. 1 8 19	5.75	+0.2
15 9 23	6.5	+0.2	2 7 40	6.4	—1.0
16 9 7	5.7	0.0	3 8 46	6.6	—0.3
18 10 1	6.55	0.0	5 8 36	6.8	—0.5
20 9 38	6.6	—0.5	6 7 59	6.7	+0.3
27 8 11	6.0	+0.3	9 8 21	6.5	+0.1
28 9 11	6.2	—0.9	11 7 45	7.0	0.0
31 9 9	6.75	—0.9	14 7 32	6.3	—0.4

Gibraltar, 1893 *November* 8.

OBSERVATIONS OF COMETS,

MADE WITH THE 16-INCH EQUATORIAL AND FILAR MICROMETER OF GOODSELL OBSERVATORY, NORTHFIELD, MINN.,

By H. C. WILSON.

[Communicated by Wm. W. Payne, Director.]

1893 Northfield M.T.		*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
				Comet *b* 1893.					
	h m s			m s	′ ″	h m s	° ′ ″		
Nov. 17	17 13 18	1	11 , 4	+0 5.71	+8 32.0	12 47 8.20	—0 0 16.1	*n*9.542	0.790
				Comet *c* 1893.					
Nov. 5	16 46 47	3	6 , 4	+4 12.70	+4 34.5	12 52 5.91	+27 27 11.3	*n*9.663	0.676
	16 46 47	4	6 , 4	+3 20.27	+5 37.7	12 52 4.33	+27 27 2.6	*n*9.663	0.676
12	16 33 33	5	2	. . .	+1 10.0	. . .	. . .	. .	0.629
	16 33 33	6	2	. . .	+5 12.1	. . .	+33 37 26.7	. .	0.629
	16 46 2	5	6	+4 45.67	. . .	. . .	. . .	*n*9.683	. .
	16 46 2	6	6	+3 25.63	. . .	13 6 17.18	. . .	*n*9.683	. .
17	16 11 18	7	9 , 4	+1 52.11	+3 40.5	13 18 12.91	+38 28 22.8	*n*9.723	0.607

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	12 47 1.10	+1.41	— 0 8 36.7	—12.0	Microm. comp. with *2
2	12 46 43.05	+1.41	— 0 20 47.6	—12.0	B.B. VI, 2622; Munich 8593
3	12 47 52.02	+1.19	+27 22 52.6	—15.8	Lal. 24014; Weisse-Bessel XII, 938
4	12 48 42.88	+1.18	+27 21 41.7	—15.8	Lal. 24041; Weisse-Bessel XII, 951
5	13 1 30.1	+1.22	+33 36.4	—19.1	DM. 33°2301
6	13 2 50.34	+1.21	+33 32 43.7	—19.1	Leiden A.G. Zones 195
7	13 16 19.62	+1.18	+38 25 3.8	—21.5	Yarnall 5635, Armagh$_2$ 1555

NUMERATION OF ASTEROIDS.

[From a letter of Dr. Berberich to the Editor.]

In no. 307 of the *Astronomical Journal*, you give the numeration of the minor planets discovered since January 1893. Now it has become necessary to make yet another alteration.

Mr. J. Coniel of the Paris *Bureau des Longitudes* has found, by a new computation of planet 1893 *L*, that this is identical with 1893 *Julia*. The equatorial constants for the latter, as given in our *Jahrbuch* for 1893, are erroneous, and consequently the dates for the last oppositions are also wrong.

The identity would have been recognized sooner, had not the brightness of the planet exceeded that computed by 1½ magnitudes. It is not easy to find a sufficient explanation of this phenomenon; perhaps the inferior brightness at former oppositions may be ascribed to an effect of the phase produced by the large angular distances of the planet from the ecliptic.

Now the planet cannot retain the number (359) which it received under the supposition that it was new. But, in order to avoid confusion, the subsequent numbers will remain unchanged; and we may perhaps insert planet 1893 *M*, should this be rediscovered during the coming opposition. So, too, the gap at (330) might be filled in this way by the planet photographed by Prof. Max Wolf, 1892 March 18 and 20, which still remains without numeration.

It will interest you to learn that the long-missed planet (175) *Andromache* was photographed by Prof. Wolf in 1892. The elements deduced from Mr. Charlois's recent observations show that, on March 4 of that year, it should have been near No. 325, then photographed at Heidelberg. The computed position,

March 4.5 M.T. Berlin, $\alpha = 11^h\ 13^m\ 37^s$, $\delta = +7°\ 57'.8$

is fully confirmed by the position read off from Prof. Wolf's plate, viz.:

March 4, $11^h\ 11^m$ M.T. Heidelberg, $\alpha = 11^h\ 13^m.6$, $\delta = +8°\ 0'$

. . . .

From the two photographic positions of the planet 1893 *X* I have computed a circular orbit, with $\mu = 423''.4$. The plane of the orbit ($\Omega = 72°\ 18'$, $i = 1°\ 34'$) much resembles that of *Thule*, the remotest of all the known asteroids.

A. Berberich.

Berlin, 1893 *Dec.* 3.

RUDOLF WOLF.

The last mail brings tidings of the death of this eminent astronomer, mathematician and historian of science, at the Zurich Observatory, to which he had given so great renown.

He was born 1816 July 7, at Fällanden, a small village where his father was pastor, in the close vicinity of Zurich. At the age of 23 years he became instructor in mathematics and physics at the *Realschule* of Berne; in 1847 he was appointed Director of the Observatory there, and in 1853 Professor in the University. In 1855 he returned to Zurich as Director of the Observatory in that city, as well as Professor in the *Polytechnicum* and subsequently in the Federal University. He passed away December 6, after a brief illness, at the age of 77 years and 5 months.

Prof. Wolf's contributions to science are numerous, and cover a wide field, embracing researches in pure mathematics, astronomy, physics and the history of science, especially in his native country, to which he was most ardent and loyally devoted. In 1852 he published the first edition of his well known *Taschenbuch* of Mathematics, Physics, Geodesy and Astronomy; in 1858–61, his four volumes of biographies of Swiss men of science; in 1869–72, his *Handbuch der Mathematik*, etc., in two volumes; and the last of his more extended works, the *Handbuch der Astronomie, ihrer Geschichte und Litteratur*, has been completed during the current year 1893, in which the last of its four half-volumes has been issued. His singularly instructive *Astronomische Mittheilungen*, begun in 1856, have been continued to the present time, containing descriptions of the collection of instruments and scientific relics of historical value, which he had gathered in the Zurich Observatory, together with numerous and elaborate accounts of Swiss mathematicians, physicists and astronomers,—the whole interspersed with important astronomical communications. In 1877 was published his History of Recent Astronomy, especially in Germany.

But Wolf's distinguished reputation has been especially due to his important discoveries and researches relative to the solar spots. SCHWABE had certainly been the first to detect the periodicity recognizable in their recurrence, although his deductions were drawn from a limited series of observations; and LAMONT and SABINE had moreover perceived the apparent existence of an intimate relation between the variations of the magnetic declination and those of the spots. But the researcher of RUDOLF WOLF first developed the periodic law to which the variations of the solar spots are subjected; and it was by his laborious and thorough researches that the evidence was made palpable in the same year, 1852, that this law had prevailed, ever since the spots had been a subject of attentive observation.

His device and introduction of the relative numbers, for expressing the degree of spottiness of the sun, placed this branch of solar physics upon a firm basis. By elaborate investigations he succeeded in determining and placing upon record not only the epochs of maxima and minima of spottiness, but in assigning its relative amount at all the dates for which existing data permitted the determination. Thus he prepared a careful record extending from the time of the discovery of the spots, showing the periodicity of the phenomenon through two centuries and a quarter, and corroborating the accordance of the resultant period and epochs, with those of the fluctuations in the variation of the magnetic declination. These determinations of the relative numbers were continued through later years; and were made far more accurate by the observations which he carried on personally, and to which he stimulated others for the purpose. And there has been no injustice to other investigators, in the recognition which has universally been accorded to him as the chief investigator and principal authority in this field.

A detailed account of his researches in the domain of solar physics was published by Prof. A. WOLFER in the *Archives de Genève* for 1891.

Prof. WOLF's memoirs have been notable by their encyclopedic character, — a vast amount of information, covering a wide range of knowledge, being condensed into concise form; and his *Taschenbuch*, *Handbuch* and *Mittheilungen* are models of compact and full statement.

His personal character was amiable and peculiarly unassuming; his daily life and habits were those of an unpretending and modest explorer of scientific truth.

1893 *December* 21.

NEW ASTRONOMICAL WORKS.

Comparison of Positions of Stars between 49° 50′ and 55° 10′ North Declination in 1855.0, observed with the Meridian-Circle, 1870–1884. Vol. XXV, Annals of Harvard College Observatory, by W. A. ROGERS.

In the third part of this volume (pp. 253–376) Prof. ROGERS gives the results of the individual observations on which his Zone-Catalogue of 8627 stars, made for the Grand Catalogue of the *Astron. Gesellschaft*, and published in 1892, was based. In the first two parts he presents a discussion of the proper motions of those stars contained in it, and observed by previous authorities, which appear to have a sensible movement. He first determines the systematic corrections of thirty-two catalogues between 1790 and 1880 (Tables I and II) for the reduction to the system of his Catalogue. The application of these to the positions of the previous catalogues, reduced to 1875.0, furnishes the material (pp. 1–211) from which the proper motions of 1134 stars are deduced (pp. 213–251).

The results of this conscientious and laborious discussion cannot fail to provide a highly important mass of material for a new investigation of the solar motion, which it is hoped that its author may undertake.

Observations of Variable Stars, by HENRY M. PARKHURST.

This series of observations, made by this well-known amateur astronomer, at his private observatory in Brooklyn, N.Y., from 1883 to 1892, is one of the most valuable contributions to the subject that we possess. It comprises 135 of the known variables, and some stars suspected of variability, as well as other objects. The observations were mostly made by photometers devised by himself, and are communicated in detail. Lists of comparison-stars are given, and also determinations of light-curves, and discussions of some points relating to instrumental photometry. The memoir is printed at the expense of the Harvard College Observatory (Vol. XXIX, No. IV).

La Voie Lactée dans l'Hemisphère Boréal, by C. EASTON, Dordrecht and Paris, 1893.

This interesting study of the Milky Way consists of a series of five lithographic plates, with accompanying explanatory and descriptive text. The extreme and peculiar difficulties in delineating this object have been fully appreciated by the author, and he has manifestly brought great judgement and artistic skill to bear in overcoming them, neglecting no precaution to secure in his drawings that quality which is of paramount importance in attempts of this character; — namely, absolute independence of the work of other observers. Thus they possess a scientific value, even after the superb drawings of BOEDDICKER.

The observations and original drawings were made between 1882 and 1887. The copies, from which the published reproductions are made, were executed by the author himself in 1892. The impressions of the principal drawing, Chart IV, were also retouched by him as the impressions were made, in order to secure absolute uniformity.

The accompanying text includes a historical notice of the subject, a detailed description of the various portions, and a catalogue of the spots, luminous streams, and obscure places of the Milky Way in the Northern Hemisphere.

CORRIGENDA.

Vol. XII, No. 283, p. 150, line 2,	*for*	Epoch Nov. 24.5	*put*	Dec. 24.5.
Vol. XIII, No. 298, p. 79, col. 2, line 4,	"	(p^2-q^2)	"	(p^2+q^2).
No. 307, p. 160, col. 2, line 4,	"	their	"	the.
p. 161, col. 2, line 32,	"	successively	"	successfully.

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NEW ASTRONOMICAL WORKS.
CORRIGENDA.

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THE ASTRONOMICAL JOURNAL.

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VOL. XIII. BOSTON, 1894 JANUARY 20. NO. 22.

ON THE ORBIT OF COMET 1892 V.

By J. G. PORTER.

This comet was discovered photographically by Prof. E. E. Barnard, at the Lick Observatory on Oct. 12, and was observed from Oct. 13 to Nov. 21. I have sought from a discussion of all the published observations to derive the most probable values of the elements.

A preliminary orbit computed from Vienna observations of Oct. 16, 27 and Nov. 7, gave the following elements:

Epoch Oct. 22.5 Berlin mean time.

$$
\begin{aligned}
M_0 &= 352^\circ\ 8'\ 13''.0 \\
\pi &= 17\ \ 1\ 34.4 \\
\Omega &= 206\ 42\ 28.6 \\
i &= 31\ 10\ 25.1
\end{aligned}
\left.\vphantom{\begin{aligned}\pi\\\Omega\\i\end{aligned}}\right\}1892.0
$$

$$
\begin{aligned}
\varphi &= 35\ 19\ 10.9 \\
\log \mu &= 2.7557983 \\
\log a &= 0.5294722
\end{aligned}
$$

The perturbations of the rectangular coordinates by *Mars* and *Jupiter*, for the interval of observations, were next obtained, and the following ephemeris was computed, in which the effect of these perturbations is included.

Ephemeris for Berlin Midnight.

1892	App. α	App. δ	log Δ	Aberr. time
	h m s	° ′ ″		m s
Oct. 12.5	19 31 31.95	+12 56 28.8	0.04488	9 12
13.5	33 36.55	33 56.4		
14.5	35 43.46	11 26.6	0.04528	9 13
15.5	37 52.62	11 48 59.7		
16.5	40 4.02	26 36.4	0.04579	9 13
17.5	42 17.63	4 17.1		
18.5	44 33.44	10 42 2.3	0.01641	9 14
19.5	46 51.43	19 52.5		
20.5	49 11.56	9 57 48.4	0.04716	9 15
21.5	51 33.78	35 50.3		
22.5	53 58.09	13 58.8	0.04803	9 16
23.5	56 24.44	8 52 14.3		
24.5	58 52.81	30 37.4	0.04903	9 17
25.5	20 1 23.17	+ 8 9 8.5		
Oct. 26.5	20 3 55.51	+ 7 47 48.3	0.05015	9 19
27.5	6 29.74	26 37.0		
28.5	9 5.86	5 35.2	0.05141	9 20
29.5	11 43.81	6 44 43.1		
30.5	14 23.57	24 1.5	0.05279	9 22
31.5	17 5.10	3 30.6		
Nov. 1.5	19 48.35	5 43 11.0	0.05431	9 24
2.5	22 33.30	23 2.9		
3.5	25 19.88	3 6.7	0.05597	9 26
4.5	28 8.09	4 43 22.9		
5.5	30 57.87	23 51.9	0.05776	9 29
6.5	33 49.21	4 24.0		
7.5	36 42.05	3 45 29.7	0.05970	9 31
8.5	39 36.34	26 39.3		
9.5	42 32.08	8 3.2	0.06178	9 34
10.5	45 29.24	2 49 41.8		
11.5	48 27.76	31 35.6	0.06400	9 37
12.5	51 27.61	13 45.0		
13.5	54 28.74	1 56 10.4	0.06637	9 40
14.5	57 31.12	38 52.1		
15.5	21 0 34.74	21 50.4	0.06887	9 43
16.5	3 39.52	5 5.8		
17.5	6 45.43	0 48 38.6	0.07153	9 47
18.5	9 52.42	32 29.1		
19.5	13 0.48	16 37.7	0.07432	9 51
20.5	16 9.52	+ 0 1 4.5		
21.5	19 19.53	— 0 14 10.2	0.07725	9 55
22.5	22 30.44	29 6.1		
23.5	21 25 42.24	— 0 43 42.7	0.08031	9 59

A number of the comparison-stars used in the observations being but poorly determined, they were re-observed with our meridian circle so far as seemed necessary. The adopted positions for 1892.0 with the reduction to apparent equinox are given in the table below.

No.	α 1892.0		δ 1892.0		Authority
	h m s	s	° ′ ″	″	
1	19 33 52.76	+1.53	+12 28 36.9	+9.0	2 Cincin. obs.
2	19 37 29.07		+11 34 21.3		Pulkowa
	29.11		21.6		Romberg
	29.16		19.7		Greenw. 10-yr.
	19 37 29.11	+1.53	+11 34 20.9	+8.9	
3	19 38 11.19		+11 45 49.6		Glasgow
	11.56		46.2		2 Cincin. obs.
	19 38 11.53	+1.55	+11 45 47.9	+9.2	
4	19 42 10.38	(1)	+11 12 29.4	(1)	Munich, 1
	10.36	(1)	30.1	(1)	Munich, 2
	10.29	(2)	29.0	(2)	1 Cincin. obs.
	19 42 10.33	+1.55	+11 12 29.4	+9.2	
5	19 43 47.71		+11 24 58.1		Pulkowa
	47.70		57.0		Glasgow
	19 43 47.71	+1.56	+11 24 57.6	+9.2	
6	19 43 58.20	(1)	+10 47 41.0	(1)	Munich, 1
	57.99	(2)	42.1	(2)	1 Cincin. obs.
	19 43 58.06	+1.53	+10 47 42.7	+9.0	
7	19 44 40.24		+10 57 37.6		B.B. VI
	40.27		35.3		1 Cincin. obs.
	19 44 40.26	+1.55	+10 57 36.4	+9.1	
8	19 44 41.97	(1)	+10 41 49.3	(1)	Munich
	41.75	(2)	47.9	(2)	1 Cincin. obs.
	19 44 41.82	+1.54	+10 41 48.4	+9.1	
9	19 45 51.28	+1.52	+10 8 44.0	+8.8	Cin. P.M.Catal.
10	19 45 59.24	+1.55	+11 7 41.6	+9.2	2 Cincin. obs.
11	19 47 6.84		+10 4 31.2		B.B. VI
	6.56		29.6		Brussels
	6.52		30.0		Glasgow
	6.60		30.9		Pulkowa
	19 47 6.62	+1.53	+10 4 30.4	+8.9	
12	19 48 43.05	+1.53	+10 4 37.4	+9.0	Eq. ; comp. with [last
13	19 50 1.73	+1.56	+10 26 55.6	+9.2	Pulkowa
14	19 50 46.63		+ 9 55 17.0		Munich, 1
	46.76		17.2		Munich, 2
	19 50 46.70	+1.54	+ 9 55 17.1	+9.0	
15	19 51 3.61	(1)	+ 9 21 28.0	(1)	Munich, 1
	3.70	(2)	28.1	(2)	1 Cincin. obs.
	19 51 3.68		+ 9 21 28.1		
16	19 51 19.89	(1)	+ 9 35 57.0	(0)	B.B. VI
	20.20	(1)	56.8	(0)	Munich, 1
	20.04	(2)	52.4	(1)	2 Cincin. obs.
	19 51 20.04	+1.54	+ 9 35 52.4	+9.0	Prob. p.m. in δ
17	19 53 8.16	+1.54	+ 9 19 20.1	+9.0	Eq. ; comp. with Star 15
18	19 53 57.01	(1)	+ 9 0 6.3	(1)	Munich
	56.76	(2)	4.3	(2)	1 Cincin. obs.
	19 53 56.84	+1.53	+ 9 0 5.0	+8.9	
19	19 55 33.05		+ 9 10 5.8		Munich
	32.87		7.4		Schjellerup
	19 55 32.96	+1.53	+ 9 10 6.6	+9.0	
20	19 55 45.61	(1)	+ 8 15 38.9	(1)	Munich
	45.52	(2)	40.3	(2)	Pulkowa
	19 55 45.55	+1.54	+ 8 15 39.8	+9.0	
21	19 59 12.96	(1)	+ 8 29 27.1	(1)	Munich, 1
	12.83	(2)	25.0	(2)	1 Cincin. obs.
	19 59 12.87	+1.54	+ 8 29 25.7	+9.0	
22	20 2 2.72	+1.56	+ 8 6 59.5	+9.0	B.B. VI
23	20 10 21.11		+ 7 28 44.2		Munich
	21.14		41.9		Göttingen, 2
	20 10 21.12	+1.58	+ 7 28 43.1	+9.2	
24	20 31 58.77		+ 3 43 38.4		Boss, A.G. Cat.
25	20 35 17.31	+1.63	+ 3 47 57.3	+9.1	Eq. ; comp. with the preceding
26	20 38 17.64		+ 3 41 23.6		Glasgow
	17.56		24.5		Boss, A.G. Cat.
	20 38 17.60	+1.63	+ 3 41 24.1	+9.1	
27	20 42 59.16	+1.64	+ 3 15 3.8	+9.3	Boss, A.G. Cat.
28	20 51 43.87	+1.67	+ 2 3 8.0	+9.2	Boss. A.G. Cat.
29	21 12 27.48	+1.73	— 0 17 8.9	+9.1	Cin.P.M.Catal.

The observations as reduced with the above star-positions, and their comparison with the ephemeris, are given in the following table.

No.	Place	Berlin time of Observ.	App. α	Par.	App. δ	Par.	C—O	
							$\Delta\alpha \cos\delta$	$\Delta\delta$
		d h m s	h m s	s	° ′ ″	″	″	″
1	Lick	Oct. 13 16 12 38	19 33 57.06	+0.13	+12 29 59.9	+3.4	+ 9.5	+ 4.8
2	Lick	15 17 59 37	38 23.88	+ .31	+11 43 33.4	+3.8	+ 2.9	— 4.7
3	Vienna	16 8 22 10	39 42.80	+ .23	+11 30 13.4	+5.0	+ 1.8	—10.4
4	Lick	16 19 21 13	40 43.60	+ .39	+11 19 49.6	+4.2	— 1.8	+ 0.4
5	Hamburg	17 8 35 22	41 57.64	+ .19	+11 7 42.5	+5.7	— 2.5	—12.4
6	Paris	17 9 39 21	42 3.06	+ .25	+11 6 43.6	+5.1	+ 4.6	—12.4
7	Lick	17 19 37 39	42 59.05	+ .41	+10 57 15.0	+4.3	+ 3.4	+ 1.7
8	Hamburg	18 7 5 34	44 4.14	+ .08	+10 46 47.1	+5.4	+ 5.7	— 9.1
9	Kopenhagen	18 8 27 18	44 11.19	+ .19	+10 45 31.1	+5.8	+14.4	— 9.2
10	Paris	18 9 5 8	19 44 15.33	+0.21	+10 44 59.6	+5.1	+ 6.4	—12.0

No.	Place	Berlin time of Observ.	App. α	Par.	App. δ	Par.	C—O	
							$\Delta\alpha\cos\delta$	$\Delta\delta$
		d h m s	h m s	s	° ′ ″	″	″	″
11	Algiers	Oct. 18 9 38 51	19 44 18.50	+0.31	+10 44 28.6	+3.8	+ 5.2	—10.9
12	Lick	18 15 44 38	44 54.18	+ .09	+10 38 44.7	+3.6	— 4.9	— 5.2
13	Pulkowa	19 6 46 49	46 19.65	+ .14	+10 24 56.3	+6.1	+ 8.1	—12.6
14	Harvard	19 14 4 26	47 1.04	+ .25	+10 18 12.3	+4.4	+18.8	—10.3
15	Lick	19 15 57 34	47 13.03	+ .12	+10 17 23.4	+3.6	+ 5.2	—61.8*
16	Pulkowa	20 6 15 35	48 36.33	+ .11	+10 3 19.9	+6.1	+ 7.6	—12.9
17	Vienna	20 7 32 35	48 43.94	+ .17	+10 2 9.0	+5.0	+ 5.2	—11.6
18	Paris	20 8 40 46	48 50.74	+ .19	+10 1 6.4	+5.1	+ 3.1	—11.7
19	Northfield	20 15 8 48	49 29.03	+ .21	+ 9 55 11.5	+4.6	— 0.9	—12.4
20	Paris	21 8 40 12	51 12.38	+ .19	+ 9 39 9.5	+5.1	+ 6.4	—14.1
21	Paris	22 8 0 14	53 31.98	+ .13	+ 9 18 2.6	+5.1	+12.7	—22.6
22	Lick	22 18 32 42	. . . .	. . .	+ 9 8 2.6	+4.2	. . .	+ 4.0
22	Lick	22 18 41 16	54 36.31	+ .36	. . . .	. . .	+15.3	. . .
23	Vienna	23 7 51 30	55 57.86	+ .20	+ 8 56 14.0	+5.1	+ 0.4	—11.8
24	Lick	24 16 9 46	59 17.31	+ .16	+ 8 27 t.7	+3.8	+ 4.6	— 3.9
25	Lick	24 16 35 11	19 59 19.24	+ .20	+ 8 26 33.5	+3.9	+14.6	+ 1.4
26	Lick	25 16 50 40	20 1 51.05	+ .22	+ 8 5 8.3	+4.0	+22.4	—14.6
27	Vienna	27 9 15 25	6 10.56	+ .30	+ 7 29 14.8	+5.4	+ 2.2	—10.1
28	Vienna	Nov. 7 6 7 20	35 58.10	+ 08	+ 3 50 17.3	+5.4	+ 3.7	— 6.5
29	Lick	7 15 37 14	37 7.25	+ .13	+ 3 42 44.3	+4.2	— 4.2	— 2.7
30	Vienna	9 5 47 39	20 41 45.25	+ .05	+ 3 12 54.1	+5.4	+ 0.6	— 1.7
31	Lick	21 15 37 40	21 19 46.77	+0.14	— 0 16 42.8	+4.5	+ 1.6	+17.7

*Corrected by 1′ before using.

In order to judge of the proper weights to assign, a rough computation of probable errors was made by taking the mean of all the residuals in each coordinate, and subtracting it from the individual values. Since there are not enough observations to treat each series by itself, I first formed three groups, the Lick, the Vienna, and all the rest taken together. For these I found,

	$\Delta\alpha\cos\delta$	$\Delta\delta$
Lick,	±5″.7	±7″.0
Vienna,	±3 .0	±3 .3
All others,	±3 .7	±4 .5

An inspection of the individual values of the third group shows that, with the exception of rather large residuals given by Harvard in right-ascension on Oct. 19, and by Paris in declination on Oct. 21, they may be considered comparable with the Vienna series. Taking the second and third groups together, we find ±3″.5 and ±4″.2, and assigning unit weight to these, the first group would be entitled, according to the usual formula, $p = \frac{1}{e^2}$, to a little over one-third weight. I have considered it better, however, in view of the large residual in declination on Nov. 21, when the comet was very faint, to increase the weight to one-half. It should be stated that, after forming the equations of condition, I tried, by giving more weight to this last observation, to find an orbit that would reduce this large residual, but without success.

The equations of condition were formed by taking together all the observations of each day, and forming the weighted mean.

Equations of Condition in Right-Ascension.

								Weight
	″							
1	0 = + 9.5	$+1.063\,\Delta\pi$	$-0.238\,\Delta\Omega$	$-0.193\,\Delta i$	$-3.245\,\Delta\varphi$	$+3.201\,\Delta M_0$	$-242.0\,\Delta\mu$	0.5
2	0 = + 2.9	+1.054	—0.237	—0.184	—3.206	+3.232	—235.1	0.5
3	0 = + 0.6	+1.051	—0.237	—0.181	—3.192	+3.244	—232.6	1.5
4	0 = + 1.5	+1.047	—0.236	—0.177	—3.171	+3.261	—229.0	2.5
5	0 = + 6.5	+1.041	—0.235	—0.173	—3.152	+3.275	—225.7	4.5
6	0 = +11.8	+1.038	—0.234	—0.169	—3.130	+3.294	—221.8	2.5
7	0 = + 3.8	+1.035	—0.234	—0.166	—3.110	+3.309	—218.2	4.0
8	0 = + 6.4	+1.030	—0.232	—0.160	—3.090	+3.327	—214.5	1.0
9	0 = +13.6	+1.027	—0.232	—0.157	—3.066	+3.346	—210.5	1.5
10	0 = + 0.4	+1.023	—0.230	—0.153	—3.045	+3.362	—206.7	1.0
11	0 = + 9.6	+1.018	—0.229	—0.147	—3.015	+3.384	—201.5	1.0
12	0 = +22.4	+1.015	—0.228	—0.143	—2.990	+3.404	—198.0	0.5
13	0 = + 2.2	+1.008	—0.226	—0.136	—2.948	+3.435	—190.6	1.0
14	0 = + 1.1	+0.972	—0.212	—0.091	—2.634	+3.631	—141.1	1.5
15	0 = + 0.6	+0.966	—0.207	—0.084	—2.575	+3.664	—132.4	1.0
16	0 = + 1.6	+0.926	—0.183	—0.040	—2.130	+3.850	— 69.1	0.5

Equations of Condition in Declination.

								Weight
1	$0 = +4''.8$	$+0.235\,\Delta\pi$	$+0.430\,\Delta\Omega$	$+1.052\,\Delta i$	$-0.606\,\Delta\varphi$	$+0.792\,\Delta M_0$	$-34.3\,\Delta\mu$	0.5
2	$0 = -4.7$	+0.216	+0.440	+1.029	—0.586	+0.707	—35.7	0.5
3	$0 = -6.8$	+0.207	+0.446	+1.018	—0.573	+0.676	—36.4	1.5
4	$0 = -9.6$	+0.197	+0.452	+1.005	—0.562	+0.636	—37.2	2.5
5	$0 = -9.7$	+0.188	+0.457	+0.993	—0.553	+0.599	—38.1	4.5
6	$0 = -10.1$	+0.177	+0.463	+0.979	—0.541	+0.557	—39.0	2.5
7	$0 = -12.1$	+0.168	+0.468	+0.967	—0.532	+0.520	—39.9	4.0
8	$0 = -14.1$	+0.158	+0.473	+0.952	—0.521	+0.480	—40.9	1.0
9	$0 = -13.7$	+0.147	+0.479	+0.938	—0.512	+0.437	—41.9	1.5
10	$0 = -11.8$	+0.138	+0.483	+0.925	—0.505	+0.400	—42.9	1.0
11	$0 = -1.3$	+0.127	+0.488	+0.910	—0.495	+0.355	—44.2	1.0
12	$0 = -14.6$	+0.117	+0.494	+0.893	—0.486	+0.314	—45.3	0.5
13	$0 = -10.1$	+0.100	+0.504	+0.862	—0.474	+0.244	—47.4	1.0
14	$0 = -5.2$	0.000	+0.542	+0.700	—0.430	—0.162	—62.7	1.5
15	$0 = -1.7$	—0.015	+0.548	+0.670	—0.427	—0.229	—66.1	1.0
16	$0 = +17.7$	—0.101	+0.570	+0.468	—0.454	—0.561	—85.7	0.5

Multiplying each equation by the square root of its weight, and expressing $\Delta\mu$ in hundredths, we derive the following

Normal Equations.

$$\begin{array}{rrrrrrrl}
+26.88\,\Delta\pi & -4.17\,\Delta\Omega & -0.36\,\Delta i & -79.84\,\Delta\varphi & +87.37\,\Delta M_0 & -54.81\,\Delta\mu(.01) & +104.19 & = 0 \\
-4.17 & +6.94 & +11.82 & +11.30 & -14.08 & +6.86 & -132.61 & = 0 \\
-0.36 & +11.82 & +22.56 & -0.28 & -1.83 & -1.32 & -232.80 & = 0 \\
-79.84 & +11.30 & -0.28 & +238.40 & -258.53 & +164.91 & -308.35 & = 0 \\
+87.37 & -14.08 & -1.83 & -258.53 & +285.33 & -176.17 & +340.55 & = 0 \\
-54.81 & +6.86 & -1.32 & +164.91 & -176.17 & +115.45 & -210.40 & = 0
\end{array}$$

On account of the near approach to identity of the equations of condition, it is impossible to solve the normal equations in the usual manner. It was therefore done by substituting successive trial-values of the unknown quantities, until the sum of the squares of the residuals could not be further reduced. The values thus obtained are:

$$\begin{array}{llllll}
\Delta\pi = & -0''.20 & \Delta i = & +10''.50 & \Delta M_0 = & +1''.48 \\
\Delta\Omega & 0\ .00 & \Delta\varphi & +1\ .47 & \Delta\mu & +0\ .0198
\end{array}$$

And the final elements are:

Osculating epoch 1892 Oct. 22.5 Berlin mean time.

$$\begin{aligned}
M_0 &= 352^\circ\ 8'\ 14''.48 \\
\pi &= 17\ \ \ 1\ \ 34.20 \\
\Omega &= 206\ 42\ 28.60 \\
i &= 31\ 10\ 35.60
\end{aligned}\left.\vphantom{\begin{aligned}\pi\\ \Omega\\ i\end{aligned}}\right\}1892.0$$

$$\begin{aligned}
\varphi &= 35^\circ\ 19'\ 12''.37 \\
\log\mu &= 2.7558134 \\
\log a &= 0.5294621
\end{aligned}$$

I have not attempted to get the weights of the quantities from the normal equations. They would of course come very small, and it may very well be that the method of first determining the corrections to the geocentric distances, and from these the elements, would be preferable in this case. I have not time, however, at present to follow up the investigation myself.

By recomputing the ephemeris with the corrected elements, and again comparing the observations, we get the following tables:

Lick.

Date	$\Delta\alpha\cos\delta$	$\Delta\delta$
	″	″
Oct. 13	+ 2.2	+15.5
15	— 3.8	+ 5.6
16	— 8.2	+10.5
17	— 2.9	+11.7
18	—10.9	+ 4.7
19	— 0.7	+ 4.8
22	+ 9.9	+12.8
24	— 0.4	+ 4.4
24	+ 9.5	+ 9.7
25	+17.6	— 6.6
Nov. 7	— 6.6	+ 2.5
21	+ 2.2	+19.5

Pulkowa.

Oct. 19	+ 2.1	— 2.9
20	+ 1.6	— 3.5

Vienna.

Date	$\Delta\alpha\cos\delta$	$\Delta\delta$
	″	″
Oct. 16	—4.9	— 0.2
20	—0.7	— 2.2
23	—4.8	— 3.3
27	—2.2	— 2.5
Nov. 7	+1.3	— 1.3
9	—1.3	+ 2.7

Paris.

Oct. 17	—1.8	— 2.3
18	+0.1	— 2.1
20	—2.8	— 2.3
21	+0.7	— 5.0
22	+7.2	—13.7

Hamburg.

Date	$\Delta\alpha\cos\delta$	$\Delta\delta$
	″	″
Oct. 17	— 8.8	—2.3
18	— 0.4	+0.8

Kopenhagen.

Oct. 18	+ 8.2	+0.7

Algiers.

Oct. 18	— 1.0	—1.0

Harvard.

Oct. 19	+12.8	—0.6

Northfield.

Oct. 20	— 6.6	—3.1

	$\Delta\alpha\cos\delta$	$\Delta\delta$
Probable error of 1 obs. of unit weight,	±3″.61	±3″.76
" " " for Lick,	±5.5	±8.0
" " " for all others,	±3.1	±2.4

From the foregoing it is evident that too much weight relatively was given to the Lick observations, especially in declination. The most curious fact is that, with one exception, the declinations of this series all deviate in the same direction. I have gone over my work to see that the longitude was properly applied, and that no constant error was made, and am unable to offer any explanation.

The period of the comet is 6y.226, and at its next two returns, in 1899 and 1905, it will not approach near enough to the earth for observation. In 1911 it comes to perihelion in August, and will be less favorably placed than when discovered. It is not likely, therefore, that it will be seen again until 1917, when it comes to perihelion in November.

ON THE VARIABILITY OF (1805) —*ORIONIS*, DM. 47°3038 AND (8116) —*CEPHEI*.

BY PAUL S. YENDELL.

(1805) — *Orionis.*

Attention was called to the probable variability of this star, which is DM. +3°766, by Boss, in this Journal, Vol. VII, p. 125; I have observed it since 1892 Jan. 1, but have never seen anything in its place until 1893 Nov. 30, when I found a star there which I estimated at $11^M.5$ to $12^M.0$, being just held on a very clear, moonless sky; from that time until 1894 Jan. 2, it has risen steadily to $8^M.8$; these observations remove all doubt of the star's variability.

DM. 47°3038.

$\alpha = 20^h\ 6^m\ 23^s.6,\qquad \delta = +47^\circ\ 23'.0\quad (1855).$

The probable variability of this star was announced by DEICHMÜLLER, *Astr. Nachr.* 3191. From 1893 October 17 to December 31 I have thirty observations of it, which appear to confirm its variation; the range seems to be from $7^M.5$ to $8^M.3$, in a period of about $6^d.16$. Maxima are indicated on October 29, November 4, 10, 30, and December 17; and minima on October 19 and 31, and Nov. 25. The data at hand are not yet sufficient for a more definite determination.

(8116) — *Cephei.*

This star is DM. 57°2568, and was suspected of variability by ESPIN (see CHANDLER's Second Catalogue, p. 21); my observations, numbering 32, since 1893 Nov. 9, indicate that it is variable from $8^M.3$ to $7^M.3$, in a period of about 7¼ days, the increase being slightly quicker than the decrease. The data now on hand are insufficient for an accurate determination of period or light-curve, but maxima and minima have been observed as follows:

MAXIMA	w	MINIMA	w
1893 Nov. 22.0	2	1893 Nov. 9.2	1
Dec. 13.7	3	17.3	2
20.1	2	25.4	4
28.0	3.	Dec. 3.3	3
		16.3	1
		23.0	2

The star is quite red, a mean of five observations indicating a coloration of 6.0.

Dorchester, Mass., 1894 *January* 5.

The above confirmation, by Mr. YENDELL, of the variability of two of the stars in CHANDLER's list of those announced but not yet confirmed (*A.J.* 300, p. 109), and of DEICHMÜLLER's star (*A.N.* 3191), permits the assignment of their definitive notation. This, and the data corresponding to the left-hand page of his Catalogue, have been supplied by Dr. CHANDLER. — ED.

No.	Star	1900.0		1900 Annual Variation		1855.0		Redness	Magnitude	
		R.A.	Decl.			R.A.	Decl.		Max.	Min.
		h m s	° ′	s	′	h m s	° ′			
1815	V Orionis	5 0 47	+ 3 58.0	+3.16	+0.09	4 58 25	+ 3 54.0	–	8.8<	12<
7247	RX Cygni	20 7 46	+47 30.9	+1.84	+0.18	20 6 24	+47 23.0	–	7.5	8.3
8116	W Cephei	22 32 39	+57 54.4	+2.28	+0.31	22 30 56	+57 40.5	6.0*	7.3	8.3

NOTES ON LONG PERIOD VARIABLES,

BY J. A. PARKHURST.

The following observations were made from May to December 1893, by ARGELANDER's method, with a 6.2-inch Brashear reflector. The magnitudes are photometric,* and only approximate.

107. *T Cassiopeae.*

Seventeen observations of this star, from 1893 July 7 to Dec. 8, show a minimum of about 12^M, Aug. 27. From that time the rise was steady. At the last observation the star was $8^M.5$.

1113. *U Arietis.*

Seventeen observations, from 1893 Oct. 1 to Dec. 12, indicate a maximum of 9^M, Nov. 16. During the time of observation the star ranged from $10^M.5$ to 9^M. The decline was a little more rapid than the rise. Dec. 12 it was about 10^{M}.

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* Scale of Mr. HENRY M. PARKHURST. See *A.J.* no. 308, p. 167.

4511. *T Ursae Majoris.*

I observed this star from 1893 May 11 to Aug. 11, after which time it was invisible under poor conditions till Oct. 9. It was followed from that time until Dec. 12. Sixteen observations yield a minimum $<12^{M}$, 1893 Aug. 22.

4557. *S Ursae Majoris.*

I have twenty-two observations of this star, from 1893 May 11 to Dec. 12. They show a well-marked minimum $<12^{M}$, 1893 Sept. 1.

5190. *R Camelopardalis.*

Eighteen observations, extending from 1893 May 10 to Dec. 8, show a minimum $<12^{M}$, 1893 Sept. 15. The star reached my limit of vision at its minimum. The rise was a little more rapid than the decline.

5157. *S Bootis.*

This star was observed eighteen times, from 1893 May 13 to Dec. 12. A fairly well-defined maximum $8^{M}.2$ seems to be indicated for 1893 Aug. 17. When last observed the star was $<12^{M}$.

5338. *U Bootis.*

When first observed, 1893 Aug. 7, this star was $11^{M}.7$. It then rose gradually to a maximum $10^{M}.7$, Oct. 6, after which it fell more rapidly till the last observation, Dec. 12, when it was $<12^{M}$. I have seventeen observations between the above dates.

5948. *R Ursae Minoris.*

Twenty observations, from 1893 May 10 to Dec. 8, yield two maxima, 1893 June 6, $9^{M}.0$, and Nov. 19, $8^{M}.7$; also one minimum Aug. 26, $9^{M}.5$. The observations were fairly accordant, but the range was so small that I do not consider the results very reliable.

7220. *S Cygni.*

This star was invisible till 1893 Sept. 4, from which date I have twenty-one observations extending to Dec. 12. It rose rapidly from $<12^{M}$ to a maximum 10^{M}, 1893 Oct. 26, after which it fell more slowly, till when last seen it was $11^{M}.7$. There are no certain indications of Townley's secondary maximum.

Marengo, Ill., 1893 *Dec.* 16.

SOME RECENT PAPERS ON THE REDUCTION OF ASTRONOMICAL PHOTOGRAPHS.

By HAROLD JACOBY.

So much attention has been given recently to astronomical photography, that it is not surprising to find quite a large number of papers in recent astronomical literature relating to photographic reductions. No doubt the best method of performing the necessary operations will not be determined until several extensive series of observations have been computed; and after all, personal opinion and habit may have much to do with the decision. But it is important at the outset not to lose sight of certain definite principles, a neglect of which might perhaps lead to actual error. Many of the recent papers deal with the refraction, aberration, scale-value, and other corrections required by the photographic results, and numerous methods of calculating these various quantities are proposed. Some of the authors even aim at avoiding these corrections altogether, and it is to their papers that special attention is called.

It may, perhaps, be stated as a general principle, deducible from the history of science, that whenever astronomers have introduced *computed* corrections of their observations, a distinct advance in accuracy has been attained. But we may regard with suspicion every attempt to substitute for computed corrections either accuracy in instrumental adjustment or some special device in arrangement of observations. It is for this reason that I have thought it of interest to consider the following three papers, whose titles are set down in the order of their publication.

I. Dr. S. C. Chandler, "A device for eliminating refraction in micrometric or photographic measures" (*Astron. Journ.* XII, 51).

II. Dr. F. Wilsing, "*Ueber die Parallaxe des planetarischen Nebels,*" B D. 41°4004 (*Astron. Nachr.* 3190).

III. Mr. H. H. Turner, "How to obtain a star's right-ascension and declination from a photograph." (*Observatory* XVI, 373).

It is well known that the configuration of stars as actually found on the photographic plate, and that which would there be found if there were no refraction, aberration, varying scale-value, etc., may be regarded as perspective projections of each other. This theorem was noted by Professor Thiele, who made use of it for the comparison *inter se*. but not for the complete reduction of several plates of the *Pleiades* made by the Henry brothers in 1886 (*Bull. Com. Perm.* I, 58). Of course it is not rigorously true, — the mathematical relation being really of a far less simple character; but it may be regarded as a very close approximation to the truth. Adopting the notation of Thiele, the general expressions for the rectangular coordinates x, y, of the perspective projection of a point x_0, y_0, are:

$$(1) \quad x = \frac{p + ax_0 + by_0}{1 + mx_0 + ny_0} \quad , \quad y = \frac{q + cx_0 + dy_0}{1 + mx_0 + ny_0}$$

These equations are a statement of the above theorem in mathematical language, if we let x_0 and y_0 be the observed rectangular coordinates of a star on the plate, and x, y, the same coordinates corrected for refraction, etc.

Both Dr. CHANDLER and Mr. TURNER make use of this theorem. Dr. CHANDLER determines from the known laws of refraction those constants of the above equations (1) which depend on refraction. In other words, he determines the position of the plane upon which a perspective projection of the actual photograph would appear undistorted by refraction. He proposes to place the plate in the plane thus determined, and in this way avoid altogether the correction for refraction. Dr. CHANDLER ends his paper with the remark that, "it is unnecessary to indicate the obvious and simple mechanical contrivances by which this method may be applied." Doubtless such contrivances could be invented, but they would necessarily tend to complicate the plate carrying apparatus. Complication always diminishes precision; and astronomy's newest and very powerful means of research should be most carefully guarded from even the slightest sacrifice of rigid accuracy. Dr. CHANDLER's suggested method is sufficiently exact theoretically, but there is a strong probability that its practical execution would offer very great difficulties.

Mr. TURNER, on the other hand, proposes a method which would be very convenient to apply in practice, were it not for the theoretical difficulties standing in the way. Following Professor THIELE's article already quoted, Mr. TURNER begins by substituting for equations (1) the following:

$$(2) \qquad x = p + ax_0 + by_0 \quad , \quad y = q + cx_0 + dy_0$$

the constants m and n having been put equal to 0. This simplification is allowable.

Now x and y are the rectangular coordinates of any star such as they would be if no refraction, etc., existed, and x_0, y_0, the actual measured coordinates. For any star whose right-ascension and declination are known, x and y can be computed, so that x_0 and y_0 having been measured on the plate, *three* known stars will be sufficient to determine the six constants of equations (2). The constants once determined, the x and y of any unknown star can be computed from the measured x_0 and y_0, and from the x and y we can again proceed to right-ascension and declination. It is at once evident that there is something peculiar in this method; for we know that *two* known stars on the plate are theoretically sufficient to allow of its complete reduction, while Mr. TURNER's method requires three such stars. The cause is easily found. The known stars are not only made to furnish the indispensable constants depending on the plate's position, but they are also made to furnish those constants that depend on refraction. But these latter constants the plates are not really competent to determine. They ought to be derived from the known laws of refraction. In fact, it would actually be possible by Mr. TURNER's method to derive from each photographic plate a numerical determination of the Besselian refraction-constant, if we knew the sidereal time of exposure and the latitude. But such a determination would have extremely little weight. If the refraction has been allowed for by suitable special correction formulae, Mr. TURNER's equations (2) become:

$$x = ax_0 + by_0 \quad , \quad y = cx_0 + dy_0 \qquad (3)$$

in which the number of constants has been reduced to four, thus admitting of a solution by means of two known stars. The introduction of the two unnecessary constants p and q would always greatly weaken the determination of the remaining four constants, no matter how many known stars there might be on the plate. This weakness would then reappear in the final positions deduced for the unknown stars. It may indeed be predicted that should any very large number of plates be reduced by this method, a re-reduction will have to be undertaken sooner or later.

In Dr. WILSING's paper the object aimed at is a determination of the parallax of one of the stars on the plate, and not the complete micrometric measurement of the positions of all the stars. In order to avoid the refraction and aberration corrections altogether, the author determines the scale value from a pair of stars so situated that the middle point of the line joining them is also the middle point of the line joining the parallax star and its comparison-star. All four stars must also lie on the same great circle. If we neglect the terms of refraction depending on powers of the distance higher than the first, the above method is exact theoretically. It is otherwise with the author's statement regarding the difficulties which he thinks might arise from the lengthening of the images caused by refraction during the exposure. The proposed method would not need to avoid these difficulties, since the middle point of the image will always correspond to the middle time of exposure when the higher terms of refraction referred to above are really negligible. This matter is of little importance, however, since it is not probable that parallax plates will ever be taken at sufficiently great zenith distances to allow of a sensible lengthening of the images by refraction. On the other hand, the condition that four stars must lie on the same great circle might often be found very difficult to fulfil.

The most important objection to this method, however, consists in the introduction into the parallax result of part of the uncertainty of the scale-value determination. Avoiding the refraction-correction saves but a few minutes of computation, while the elimination of the scale-value uncertainty really increases the precision of the parallax. For the scale-value is affected at least by the uncertainty that attaches to the bisection of the scale-value stars; and its actual error will be still greater, if we admit the probability of distant stars being affected differently from central ones by temperature-variations or other instrumental changes.

Let the observer select two comparison-stars equidistant from the parallax-star, and such that all three shall lie upon a suitable great circle. Then the uncertainty of scale-value can be practically excluded from the parallax-result, provided only that we adopt the assumption that stars equidistant from the center will be equally affected by instrumental changes.

Even this last assumption would be unnecessary, if observations could always be made in both positions of the telescope, or if the object-glass could be revolved about its optical axis, so that the observer might turn it 180° between the successive exposures on the same night. An object-glass so mounted would also permit of our studying the optical distortion by comparing the photographs of the same group of stars made in different positions of the object-glass. Such a comparison could perhaps even be made with a photographic telescope mounted in the usual way, by pointing at the pole, and photographing the close polar stars with widely varying readings of the hour circle.

In conclusion, then, we may say that no one of the three proposed methods of avoiding the refraction and other corrections may be adopted without risking some condition essential to accuracy: and astronomers who aim at the highest precision will have to continue the use of the computed corrections.

Columbia College Observatory, New York, 1893 *Nov.* 28.

OBSERVATIONS OF COMET *c* 1893 (*BROOKS*),

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

1893 Cincinnati M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Dec. 6 15 54 29	1	8 , 8	+1 6.33	—3 37.2	14 32 3.01	+59 28 13.6	*n*9.952	0.322
15 54 29	3	2 . 2	—8 7.86	—0 58.3	14 32 3.34	+59 28 18.4	*n*9.952	0.322
7 7 0 46	4	8 , 8	+3 46.07	+1 28.6	14 35 51.30	+60 10 30.3	9.742	0.877
10 10 21 13	5	10 , 10	—2 27.29	—1 39.9	14 57 28.67	+63 38 17.7	*n*9.295	0.930
11 6 10 42	7	8 , 8	—0 2.74	+4 13.2	15 3 53.86	+64 31 5.2	9.926	0.791

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	14 30 56.64	+0.04	+59 32 18.9	—28.1	Equatorial; comparison with
2	14 39 13.78	. . .	+59 32 8.9	. . .	Krueger, A.G. Catal. 8088
3	14 40 11.31	—0.11	+59 29 44.0	—27.3	Krueger, A.G. Catal. 8094
4	14 32 5.23	0.00	+60 9 30.0	—28.3	Krueger, A.G. Catal. 8047
5	14 59 56.71	—0.75	+63 40 25.2	—27.6	Equatorial; comparison with
6	15 5 48.43	. . .	+63 31 32.8	. . .	Krueger, A.G. Catal. 8247
7	15 3 57.49	—0.89	+64 27 19.7	—27.7	Krueger, A.G. Catal. 8234

NOTE. — On all these dates the comet was very faint and diffuse. Observations difficult, and not very trustworthy.

NEW ASTEROID.

Prof. KRUEGER has communicated the photographic discovery of an asteroid by Mr. CHARLOIS.

1893 *AP* 12M Dec. 6 9^h $58^m.0$ Nice M.T. $\alpha = 4^h\ 21^m\ 48^s$, $\delta = +18°\ 5'$. Daily motion, -48^s in α, and 4′ southward.

The asteroids nos. 334 and 344 have received the names *Chicago* and *Desiderata*, respectively.

CORRIGENDUM.

No. 309, p. 181, col. 1, line 7, *for* 1893 *Julia*, *put* (89) *Julia*.

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CONSIDERATIONS ON THE BEST METHOD OF DETERMINING POSITIONS OF THE PLANETS BY OBSERVATION,

By SIMON NEWCOMB.

Except in the case of certain minor planets belonging to the group between *Mars* and *Jupiter*, the existing tables of the planets are founded on meridian observations of those bodies. Such observations have proved more satisfactory than differential comparisons with stars made with the equatorial. Still the labor involved in making them is very great, and the results, when examined from the critical standpoint of our present astronomy, are not altogether satisfactory. With the exception of *Neptune*, all the major planets of the system have sensible disks, and the personal equation of an observer is therefore different in the case of a planet and of a star. Small systematic errors may thus arise which no amount of research and no multiplication of observations can wholly eliminate. This difficulty is felt especially in the cases of *Venus* and *Mercury*.

The system of observation introduced by Dr. GILL in his expedition to Ascension Island in 1877 seems to me one which can be so applied as to make a remarkable advance in the precision with which the positions of the planets can be determined. In principle it is this: — A sufficient number of stars near the apparent path of the planet are selected as comparison-stars. Their positions, or at least the positions of the brighter of them, are determined as well as possible by meridian observations. They are then subjected to a system of triangulation by means of the heliometer, the distances and position-angles of each, with reference to such surrounding ones as can be reached by the heliometer, being carefully measured. This triangulation is used to correct the results of the meridian observations, and thus reduce the whole body of stars to a consistent system. The position of the planet is then measured from two or more of the comparison-stars from night to night by the heliometer, during the period of opposition, or as long as may be considered necessary.

The most remarkable feature of this method is the extreme precision which has thus been attained. Whereas, in meridian observations, the limit of precision of the results obtainable at a single opposition must be measured by rough fractions of a second, the probable error of the determinations by Dr. GILL's method for a single evening seems to be only about a tenth of a second. An illustration of this fact has just come to my knowledge, which is so striking as to be worthy of mention.

In the discussion of his work at Ascension, Dr. GILL found a curious periodic correction to the tabular right-ascensions of *Mars*, having a coefficient $0''.376$, and a period of 13.626 days. (See *Memoirs of the Royal Astronomical Society*, Vol. XLVI, pp. 145, 147). "It is worthy of remark that the period in right-ascension (13.626 days) given in equation (2) is curiously close to that of a term depending on twice the moon's mean longitude; but I confess I can find no cause for such a perturbation."

The ephemeris of which Dr. GILL made use was not computed under his own direction, and it does not appear that at the time, he had access to the original computations. Being desirous of utilizing his work for the purpose of determining the lunar equation in the motion of the earth, I have recently obtained, through his intervention, a copy of some of the numbers employed in the computation of the ephemeris. It appeared from this that, through inadvertence, the terms of the nutation depending on twice the moon's longitude had been included in the case of the sun, but not in that of *Mars*. Computing the necessary approximate corrections to the geocentric longitudes of *Mars*, the coincidence with the term obtained by Dr. GILL was very close; the amplitude of the variation being appreciably the same, and the epochs of maxima and minima never differing by more than two days. Thus a minute periodic inequality, which would never have been noticed in even the best meridian observations, was brought to light and mapped in a diagram so as to be unmistakable.

By this method we may consider that the geocentric places of the planets are observed without any fear of systematic error except such as might arise from the figure and elongation of the disk. In the case of *Venus*, it may be questioned whether this source of error can be wholly avoided by any method of observation readily applicable. It may also be found that places of *Mercury* cannot be satisfactorily observed in this way, because comparison-stars cannot be seen in the daytime, and in the evening the planet will generally be too near the horizon. At best, therefore, observations can be made only within or near the tropics. It is therefore to the outer planets that the method will be principally applicable.

Of the three processes necessary in determinations, the first, that of meridian determinations of the positions of the comparison-stars, will not involve any radically new proceeding. In the second step, it may be that photography can advantageously replace heliometer measurements. This will undoubtedly be determined in the course of making the international photographic chart of the heavens.

Should the photographic method be successful in this case, the question will arise whether it may not advantageously be applied also to determine the positions of the planet among the stars, so that the use of the heliometer shall be done away with entirely. It is quite likely, however, that the superior brilliancy of the planet would so fog the plate as to blot out the images of the surrounding stars. This difficulty may, however, be evaded by the use of a photographic heliometer, which I believe to be the instrument of the future for such work.

Whether photography is or is not applied, experience shows that the position of a planet among the stars may be observed through a single opposition without a probable error exceeding a few hundredths of a second. This precision is beyond any attainable by the existing tables; indeed, it is scarcely possible to construct tables which shall be convenient in use, and of accuracy such that the errors shall not exceed those of the observations.

In view of the possibility that this method will ere long be adopted, it is advisable to determine in advance the positions of the necessary stars near the path of each of the outer planets at future oppositions. It may be advantageous to construct a zodiac for each planet, which shall include all the places it can occupy within two months of any opposition.

NOTES ON VARIABLE STARS.— No. 2.

By HENRY M. PARKHURST.

Results of Observations.

No.	Star	Phase	Observed Date		E	Corr.	Remarks
			Julian	Calendar			
6044	*S Herculis*	Max.	2787	1893 Nov. 19	44	+ 44$^{\text{d}}$	I have found no satisfactory modification of the elements
6132	*R Ophiuchi*	Min.	–	–	44	–	I could not recognize the variable a month prec. the min.
6682	*X Ophiuchi*	Max.	2662	July 17	7	+172	
“	“	Max.	2662	July 17	8	+ 2	Derived from my own period of 331 days, reckoning from the same epoch (M—m) becomes 125 days
6849	*R Aquilae*	Max.	2676	July 31	40	+ 13	Corresponds to a reduction of the secondary term to .33 E^2, apparently indicating progressive diminution of that term. Observations continued for light-curve
6905	*R Sagittarii*	Max. A	2724	Sept. 17	37	— 38	Great fluctuations; no single max. satisfactory
“	“	Max. B	2743	Oct. 6	37	— 19	
“	“	Max.	2731	Sept. 24	37	— 31	Rejecting observations of Oct. 1
6921	*S Sagittarii*	Max.	2776	Nov. 8	43	— 10	May have been later; low in the west
6923	*Z Sagittarii*	Max.	2683	Aug. 7	–	–	The shortest plausible period appears to be 456 days
7085	*RT Cygni*	Min.	2700:	Aug. 24	–	–	Probably near the minimum
“	“	Max.	2809	Dec. 11	–	–	Period possibly 191.6 days, M—m = 110
7106	*S Vulpeculae*	Max.	2715:	Sept. 8	155	+ 16	Estimated
“	“	Min.	2751	Oct. 14	156	+ 11	
“	“	Max.	2786	Nov. 18	156	+ 20	
“	“	Min.	2825	Dec. 27	157	+ 18	
7192	*Z Cygni*	Max.	2723	Sept. 16	9	— 4	
7234	*R Capricorni*	Max.	2803	Dec. 5	36	— 8	
7252	*W Capricorni*	Max.	2667	July 22	37	— 3	Compared with Chandler's revised elements. Appears suddenly, being invisible to me 8 days before max. in 1885, although seen by Peters
7259	*RS Cygni*	Max.	2721	Sept. 14	–	–	Repeats the sudden brightness of 1892
“	“	Min.	2825	Dec. 27	–	–	Possible period 61.7 days, M—m = 27; but great fluctuations, and possibly irregular
7261	*R Delphini*	Max.	2740	Oct. 3	36	— 13	Confirms periodic inequality
7444	*T Delphini*	Max.	2723	Sept. 16	32	— 26	Minor secondary max. noted. Periodic inequality ?
7455	*U Capricorni*	Max.	2715	Sept. 8	65	— 21	
7458	*V Delphini*	Max.	2812	Dec. 14	–	–	Possibly a few days earlier. Period prob. very nearly a year
7468	*T Aquarii*	Max.	2679	Aug. 3	57	0	Mean of two equal crests three weeks apart, with a slight intermediate descent

No.	Star	Phase	Observed Date		E	Corr.	Remarks
			Julian	Calendar			
						d	
7468	*T Aquarii*	Min.	2795	1893 Nov. 27	58	+ 1	Estimated. Invisible nearly two months
7560	*R Vulpeculae*	Max.	2770	Nov. 2	75	— 2	Changes rapid at max.
7571	*V Capricorni*	Max.	2787	Nov. 19	61	+ 7	
7577	*X Capricorni*	Max.	2802	Dec. 4	44	+ 10	
7659	*T Capricorni*	Min.	2734:	Sept. 27	52	— 7	From two distant observations only
7733	*Y Capricorni*	Max.	2687	1893 Aug. 11	14	+ 13	This indicates an addition of 1 day to the period; but I think the period is probably double, or 414 days

INDIVIDUAL OBSERVATIONS.

6044 *S Herculis*

Julian	Calendar	Mag.
d	1893	
2652	July 7	12.6
2684	Aug. 8	10.8
2711	Sept. 4	9.61_2
2738	Oct. 1	9.04_2
2744	7	9.41_2
2747	10	8.83_2
2751	14	8.32_2
2754	17	8.50_2
2761	24	8.19_2
2767	30	7.51_2
2769	Nov. 1	7.83_2
2774	6	7.08_2
2778	10	$7\ 19_2$
2783	15	7.00_2
2784	16	7.05_2
2786	18	6.51_2
2788	20	6.95_2
2798	30	7.22_2

6132 *R Ophiuchi*

2710	Sept. 3	13:

6682 *X Ophiuchi*

2627	June 12	8.2
2647	July 2	7.43_2
2654	9	7.60_2
2660	15	6.81_2
2666	21	7.36_2
2669	24	6.94_2
2672	27	7.83_2
2678	Aug. 2	7.35_2
2685	9	6.99_2

6849 *R Aquilae*

2664	July 19	6.62_2
2668	23	6.47_2
2675	30	6.00_2
2681	Aug. 5	6.36_2
2687	11	6.33_2
2694	18	7.02_2
2702	26	7.18_2
2713	Sept. 6	7.87_2
2724	17	8.02_2
2739	Oct. 2	8.32_2
2749	12	9.16_2
2769	Nov. 1	9.44_2

6905 *R Sagittarii*

Julian	Calendar	Mag.
d	1893	
2715	Sept. 8	8.0
2718	11	7.01_2
2723	16	7.08_2
2726	19	6.87_2
2738	Oct. 1	7.98_2
2740	3	6.99_2
2746	9	7.18_2
2752	15	7.43_2
2761	24	8.17_2
2762	25	7.74_2

6921 *S Sagittarii*

2715	Sept. 8	12.4]
2740	Oct. 3	12.3:
2746	9	12.7:
2765	28	11.0
2767	30	10.90_2
2777	Nov. 9	10.16
2779	11	10.25_2

6923 *Z Sagittarii*

2681	Aug. 5	9.7
2683	7	8.92_2
2685	9	9.56_2
2686	10	9.72_2
2689	13	9.61_2
2694	18	10.06_2
2706	30	10.45_2
2715	Sept. 8	10.07_2
2723	16	11.29_2

7085 *RT Cygni*

2694	Aug. 18 to	
2754	Oct. 17	12.0:
10 obs.		
2768	Oct. 31	10.23
2778	Nov. 10	8.52_2
2783	15	7.64_2
2784	16	7.93_2
2786	18	7.78_2
2788	20	7.55_2
2798	30	7.59_2
2804	Dec. 6	7.05_2
2811	13	7.06_2
2817	19	7.38_2
2829	31	7.44_2

7106 *S Vulpeculae*

Julian	Calendar	Mag.
d	1893	
2715	Sept. 8	9.19_2
2719	12	9.74_2
2727	20	9.31_2
2737	30	9.44_2
2742	Oct. 5	9.23_2
2746	9	9.91_2
2749	12	9.60_2
2752	15	10.06_2
2755	18	9.42_2
2762	25	9.91_2
2768	31	9.25_2
2777	Nov. 9	9.57_2
2784	16	9.11_2
2786	18	9.16_2
2804	Dec. 6	9.73_2
2816	18	9.42_2
2821	23	9.90_2
2824	26	10.02_2
2830	Jan. 1	9.85_2

7192 *Z Cygni*

2711	Sept. 4	9.43_2
2715	8	9.53_2
2719	12	8.70_2
2724	17	8.86_2
2739	Oct. 2	9.65_2

7234 *R Capricorni*

2681	Aug. 5 to	
2748	Oct. 11	12.4]
4 obs.		
2765	Oct. 28	11.7:
2766	29	12.1
2767	30	12.54_2
2777	Nov. 9	11.99_2
2779	11	12.02_2
2783	15	12.07_2
2798	30	12.36_2
2800	Dec. 2	11.8:
2802	4	12.00_2
2804	6	11.85_2
2806	8	12.15_2

7252 *W Capricorni*

2652	July 7	11.9
2654	9	11.90_2
2655	10	11.64_2

7252 *W Capric.* — Cont.

Julian	Calendar	Mag.
d	1893	
2660	July 15	11.87_2
2661	16	11.92_2
2664	19	11.41_2
2666	21	11.30_2
2669	24	11.40_2
2678	Aug. 2	11.85_2
2682	6	12.50_2

7259 *RS Cygni*

2711	Sept. 4	8.36_2
2715	8	8.31_2
2719	12	8.51_2
2723	16	7.07_2
2724	17	8.58_2
2727	20	8.47_2
2739	Oct. 2	8.82_2
2749	12	8.59_2
2769	Nov. 1	9.47_2
2778	10	9.13_2
2784	16	9.03_2
2800	Dec. 2	9.17_2
2816	18	8.27_2
2821	23	9.38_2
2827	29	10.32_2
2830	Jan. 1	9.26_2

7261 *R Delphini*

2666	July 21	12.0
2700	Aug. 24	11.5
2724	Sept. 17	9.31_2
2738	Oct. 1	8.59_2
2744	7	8.93_2
2747	10	8.76_2
2751	14	9.34_2
2754	17	8.91_2
2761	24	9.75_2

7444 *T Delphini*

2694	Aug. 18	11.1
2697	21	10.94_2
2709	Sept. 2	10.14_2
2715	8	9.35_2
2723	16	8.82_2
2726	19	9.92_2
2739	Oct. 2	9.35_2
2744	7	9.99_2
2749	12	9.91_2

7455 *U Capricorni*

Julian	Calendar	Mag.
d	1893	
2709	Sept. 2	11.12_2
2711	4	11.27_2
2715	8	10.86_2
2719	12	11.21_2
2723	16	11.24_2
2737	30	12.91_2

7458 *V Delphini*

2692	Aug. 16 to	
2766	Oct. 29	12.0]:
5 obs.		
2805	Dec. 5	9.5
2808	10	10.01_2
2811	13	9.71_2
2817	19	9.9
2818	20	10.28_2
2824	26	10.41_2
2827	29	11.19_2

7468 *T Aquarii*

2668	July 23	8.16_2
2672	27	8.21_2
2682	Aug. 6	8.39_2
2689	13	8.16_2
2697	21	8.52_2
2742	Oct. 5	12.2
2746	9	13.03_2
2769	Nov. 1	14.0:
2805	Dec. 7	13.8]
2810	12	13.7]
2822	24	13.7:

7560 *R Vulpeculae.*

2472	Jan. 8	8.9
2481	17	8.0
2490	26	7.9
2744	Oct. 7	10.5
2747	10	9.76_2
2755	18	9.35_2
2762	25	9.47_2
2767	30	8.45_2
2769	Nov. 1	8.26_2
2774	6	8.79_2
2778	10	8.88_2

7571 *V Capricorni*

Julian	Calendar	Mag.
d	1893	
2742	Oct. 5	11.6]
2746	9	12.9]
2766	29	12.6
2767	30	12.50_2
2778	Nov.10	10.92_2
2784	16	10.68_2
2786	18	10.35_2

7571 *V Capric.* — Cont.

Julian	Calendar	Mag.
d	1893	
2788	Nov.20	11.17_2
2798	30	10.62_2
2800	Dec. 2	10.40_2

7577 *X Capricorni*

Julian	Calendar	Mag.
2742	Oct. 5	11.9]
2746	9	13.1 :
2766	29	12.4

7577 *X Capric.* — Cont.

Julian	Calendar	Mag.
d	1893	
2767	Nov.30	12.28_2
2778	Nov.10	11.79_2
2798	30	11.69_2
2800	Dec. 2	11.79_2
2802	4	11.67_2
2804	6	11.57_2
2806	8	12.00_2

7659 *T Capricorni*

Julian	Calendar	Mag.
d	1893	
2710	Sept. 3	12.5
2742	Oct. 5	12.5]
2766	29	12.4

7733 *Y Capricorni*

Julian	Calendar	Mag.
2681	Aug. 5	12.0
2683	7	11.50_2

7733 *Y Capric.* — Cont.

Julian	Calendar	Mag.
d	1893	
2686	Aug.10	11.12
2689	13	11.37_2
2694	18	12.25_2
2709	Sept. 2	11.97_2
2719	12	12.71_2

The following table embraces groups of stars not contained in the Catalogue referred to in No. 1 (*A.J.* page 167), arranged nearly upon the same plan. The first column contains the lettering, which indicates in most cases the brightness as estimated in the DM.; and the lettering of the fainter stars also corresponds approximately to their brightness. An appended *f* denotes a fluctuating star, the observations of which are discordant, although the star is not decisively variable. In the second column is given the DM. number; and the fainter stars are identified by reference either to the variable or to some other star in the same group. Distances are given in minutes of arc. In the third column is given the photometric magnitude as determined by my own observations since 1893 Jan. 1. In the fourth column is given the number of such late observations, each observation consisting of two extinctions. The appended letter *P* indicates additional observations in the Catalogue above referred to; and *M* indicates additional observations with the meridian photometer. When 0 occurs in the fourth column, the magnitude contained in the third column is taken from the preceding catalogues, or estimation.

In the reduction of my observations less weight is given to the fluctuating stars, and also to stars which have not received six photometric observations. Until my own observations equal six, the deficiency is supplied by taking the necessary number of observations from the preceding catalogues.

COMPARISON-STARS.

6923 *Z Sagittarii*

Star	DM.	Mag.	*n*
L	—21°5340	7.98	5
X	—21°5341	10.12	7
Y	—21°5338	10.27	10+
d	1*s*3*f V*	11.28	4+
e	2*n*2*f X*	11.29	5+
g	1*s V*	11.78	3+
i	1*s*2*f V*	12.17	2+
k	1*s*1*f V*	12.67	0+
l	1*f V*	12.72	0+

7085 *RT Cygni*

Star	DM.	Mag.	*n*
C	+48°2922	6.6	0
F	+49°3092	7.63	1
1*G*	+49°3082	7.72	1
H	+48°2934	7.82	11
I	+48°2941	8.77	6
1*I*	+48°2943	8.45	7
K	+48°2939	8.26	16
1*K*	+48°2933	8.27	1
W	+48°2938	9.66	11
a	5*n*1*p V*	9.97	18
b	5*p* 1*I*	10.25	1
e	5*nf W*	11.35	5
f	2*s*5*f a*	11.68	5

7106 *S Vulpeculae*

Star	DM.	Mag.	*n*
R	+27°3532	8.80	3*M*
U	+26°3665	9.04	19*M*
1*U*	+27°3526	9.85	7*M*
W	+26°3671	9.65	18*M*
1*W*	+27°3530	9.53	3
Y	+26°3535	10.21	6
Z	+26°3532	10.10	6
a	4*n*4*p* 1*U*	10.20	4
b	1*s*1*f a*	10.78	4
i	5*f Z*	12.19	2

7458 *V Delphini*

Star	DM.	Mag.	*n*
G	+19°4530	7.53	1*M*
L	+19°4525	8.88	2*M*
N	+19°4553	9.02	3*M*
Q	+19°4554	9.06	3*M*
R	+18°4611	8.69	2
S	+18°4619	9.95	1
T	+18°4618	9.76	3
2*T*	+18°4610	9.36	2
U	+18°4614	10.54	1
W	+18°4617	9.54	5
Y	+19°4513	10.8	0
e	1*n*2*f h*	11.48	1
f	12*f T*	11.49	2
g	4*n*2*f S*	11.73	2
h	1*n*1*f g*	12.02	2
i	7*f T*	12.08	2

NOTE. — There were 13 unpublished observations in 1892, of the stars marked + near 6923, which were used in the reduction.

MAXIMA AND MINIMA OF VARIABLE STARS OBSERVED IN 1893,

BY PAUL S. YENDELL,

906. *R Trianguli.*

The season's observations of this star were begun on 1893 July 6, at which date it was found at $8^M.1$; it rose rapidly to its maximum, which was sharply indicated on August 13; after the maximum it declined to $7^M.1$, which it reached September 19; the next observation, October 5, showed a sharp rise to $6^M.8$, indicating a well-marked secondary maximum, from which it declined until the last observation, December 26, when it was estimated at $11^M.0$, being near a minimum.

5758. *X Herculis.*

This star was observed on thirty-nine evenings during the year, from March 7 to October 14; a minimum of $6^M.8$ is indicated on May 16, and a maximum of $6^M.0$ on August 28; the star's light at the last observation was $6^M.3$.

6005. *S Draconis.*

S Draconis was first observed 1893 June 15, since when, a constant watch has been kept upon it; when first seen it was about $9^{M}.1$, and the early observations show some rapid fluctuations, which seem to indicate, on the whole, that a minimum of $9^{M}.3$ took place about July 7; after the beginning of August it rose pretty steadily to $7^{M}.8$, which it reached about October 29, and continued without apparent change until December 2; the next observation, December 17, showed a decided decrease to $8^{M}.1$, and this was confirmed by another observation made December 24, since which the star has been too near the northwestern horizon to be observed further to advantage. A maximum is indicated on or about November 16. The star is decidedly red, five observations indicating a coloration of 7.0 of CHANDLER's scale; this circumstance may account for its apparent rapid fluctuations when near the minimum.

6834. *V Aquilae.*

V Aquilae was observed on twenty-five dates, from 1893 May 8 to Nov. 7; it appears to have varied irregularly, the extremes observed being $7^{M}.7$ on August 8 and $8^{M}.2$ on September 3; it was $7^{M}.9$ when observations on it were begun, and from October 11 until the last observation, did not vary sensibly from $7^{M}.8$.

6849. *R Aquilae.*

Eight field-glass observations, from August 3 to 19 appear to indicate a maximum of $6^{M}.5$ on August 9.

6905. *R Sagittarii.*

I have ten observations of *R Sagittarii*, from 1893 August 3 to October 31; these indicate a maximum of $8^{M}.0$ on September 27; at the last observation the star's light was $9^{M}.0 \pm$.

7085. *RT Cygni.*

At the first observation, on 1893 October 31, this star was estimated as $8^{M}.4$; it rose quite rapidly to $7^{M}.6$, showing a maximum on November 3; the decrease has been more gradual than its increase, the last observation, December 29, showing a light of $7^{M}.9$.

7192. *Z Cygni.*

I have ten observations of this star, from 1893 August 3 to October 21. It was estimated at $8^{M}.9$ when first observed, rising to a maximum of $8^{M}.1$ on September 13; this phase is very distinctly indicated, as the star decreased rapidly, and at the last observation had sunk to $9^{M}.3$.

7259. *RS Cygni.*

This star has been kept under pretty constant observation during the season, on account of the supposed irregularity of its variation. On April 23, when first observed, it was found to be $7^{M}.6$; it decreased to a secondary minimum of $8^{M}.0$ on June 10, afterward rising to a maximum of $7^{M}.4$, which is indicated on July 27; from this it has decreased, with two large fluctuations, to $9^{M}.6$, its estimated light when last observed, on December 29.

7261. *R Delphini.*

This star was first seen when so near its maximum that the indication of this phase given by the plotted observations is quite uncertain; it was looked for unsuccessfully so late as September 11, when it must have been $<11^{M}.5$. It was seen on October 5, quite bright, the estimated magnitude being 8.7; the maximum as indicated by the observations seems to have taken place about October 13, the decrease after October 17 being pretty steady, and on November 18 it was observed at $9^{M}.3$.

7458. *V Delphini.*

This star (for the confirmation of whose variability see this Journal, No. 309), passed a maximum of $9^{M}.1$ on December 7; the phase is sharply marked, both the increase and the decrease being regular and pretty quick. Its light at the last observation, December 31, was $9^{M}.8$.

A comparison of this observed maximum with the photographic magnitudes published with the original announcement (*Astr. Nachr.* Vol. 127, p. 6) suggests that the period of variation may be nearly commensurate with a year.

7754. *W Cygni.*

This star has been kept under observation through the season; the first observation, May 6, showed it near a minimum, which is rather uncertainly indicated on May 18, with a light of $6^{M}.5$; a maximum of $5^{M}.3$ followed on July 6, and a minimum of $6^{M}.5$ on September 9; from this time it rose steadily to a maximum of $5^{M}.6$, which was passed December 2; its light when last observed, December 31, was $6^{M}.2$.

7783. *RU Cygni.*

Twenty-two observations of this star indicate a maximum of $7^{M}.5$ about August 1; the observations show a number of minor fluctuations, perhaps attributable to the star's strong and peculiar redness; on December 2 it had fallen to $8^{M}.8$.

7795. *RV Cygni.*

I have thirty-seven observations of this star during the season, from May 6 to December 23; at the first observation it was about $8^{M}.0$, and so remained till the end of June, after which it decreased fully half a magnitude in the space of two weeks; a minimum of $8^{M}.9$ took place September 2; from this time it rose quickly to a maximum of $7^{M}.5$, which was passed October 10; since the latter date it has fallen to $9^{M}.0$, its light on December 23, at which time it was probably near a minimum. The star's variations appear to be very irregular.

Dorchester, Mass., 1894 *January* 6.

SUNSPOT OBSERVATIONS,

MADE AT PHILADELPHIA, PENN., WITH A 4½-INCH REFRACTOR,

BY A. W. QUIMBY.

1893	Time	New Grs	Total		Fac. Grs.	Def.	1893	Time	New Grs	Total		Fac. Grs.	Def.	1893	Time	New Grs.	Total		Fac. Grs.	Def.
			Grs.	Spots						Grs.	Spots						Grs.	Spots		
July 1	9	–	7	33	3	poor	Aug. 28	10	1	7	37	3	poor	Oct. 27	7	–	3	10	–	v.poor
2	9	1	5	24	2	poor	29	8	–	7	41	3	poor	28	7	1	6	46	2	poor
3	7	–	5	34	3	poor	30	7	–	6	17	3	v.poor	29	9	–	6	44	3	poor
4	8	1	4	34	3	poor	31	8	1	7	41	3	poor	30	9	1	7	33	4	poor
5	8	–	4	33	3	poor	Sept. 1	8	–	4	–	–	v.poor	31	9	–	4	19	3	poor
6	8	1	5	47	3	poor	2	8	–	6	49	3	poor	Nov. 1	9	–	4	31	3	fair
7	7	2	9	108	4	fair	3	8	–	6	84	3	fair	2	9	1	4	19	3	poor
8	7	1	8	81	4	fair	4	7	–	5	49	2	poor	3	9	–	3	10	2	v.poor
9	7	1	7	137	4	fair	5	2	–	5	96	2	fair	6	10	2	4	21	1	poor
10	7	–	7	147	3	fair	6	8	2	7	81	2	poor	7	9	1	4	14	2	poor
11	7	1	8	124	3	fair	7	8	–	7	121	3	fair	9	2	1	4	24	1	poor
12	9	–	7	104	3	poor	8	8	–	6	61	3	poor	10	9	–	5	44	3	poor
13	9	–	7	70	3	poor	9	8	–	5	60	4	poor	11	9	4	8	104	3	fair
14	9	–	7	57	–	poor	10	8	1	5	102	4	fair	12	9	1	9	95	4	poor
15	8	1	8	49	2	poor	11	8	1	5	54	1	poor	13	9	–	6	24	–	v.poor
16	8	–	6	73	4	poor	12	8	1	5	58	2	poor	14	9	1	7	35	–	poor
17	8	1	7	97	4	fair	13	8	–	7	42	2	poor	15	10	2	10	89	3	fair
18	8	–	6	58	3	fair	14	12	–	5	23	2	poor	16	10	1	8	58	3	fair
19	7	1	5	23	4	poor	15	1	1	5	16	2	poor	17	10	1	9	64	4	fair
20	7	1	6	23	3	poor	16	1	–	4	20	2	poor	18	10	2	11	73	4	fair
21	2	2	7	21	3	poor	17	8	1	4	42	2	fair	19	2	–	7	79	2	poor
22	7	1	8	42	3	fair	18	8	1	5	42	2	fair	20	12	–	6	202	4	fair
23	9	1	8	31	3	poor	19	2	2	5	35	2	poor	21	11	–	5	90	–	poor
24	7	–	6	25	3	fair	20	8	2	7	28	2	poor	22	10	–	5	165	2	fair
25	7	2	7	33	4	fair	21	8	–	7	32	2	poor	23	10	–	3	41	–	poor
26	8	–	4	21	4	poor	22	8	1	7	46	3	poor	24	10	2	6	86	2	poor
27	7	–	5	20	4	poor	23	8	1	5	49	2	poor	25	10	–	5	84	3	poor
28	9	–	5	20	4	poor	24	8	–	6	86	2	poor	26	9	–	4	56	3	poor
29	9	2	6	12	2	fair	25	11	–	5	67	2	poor	28	10	–	3	15	–	v.poor
30	9	3	9	35	3	fair	26	2	–	5	11	–	v.poor	29	4	1	4	22	2	poor
31	5	–	7	35	3	poor	27	10	–	7	30	4	poor	30	9	–	3	64	2	poor
Aug. 1	7	–	6	28	2	poor	28	8	–	3	42	3	poor	Dec. 1	1	1	3	10	–	v.poor
2	6	1	4	9	2	v.poor	29	8	1	4	28	–	poor	2	10	–	3	45	2	poor
3	7	–	5	70	4	fair	30	8	1	5	68	2	fair	4	10	–	4	19	–	poor
4	7	–	4	27	–	v.poor	Oct. 1	8	–	6	48	2	poor	6	10	–	3	17	2	poor
5	7	2	6	191	3	good	2	9	–	5	32	2	poor	7	10	–	2	21	2	poor
6	7	2	7	159	3	fair	3	8	–	5	21	2	poor	8	10	–	2	7	2	poor
7	7	2	11	259	3	fair	5	5	–	5	13	–	v.poor	10	2	1	3	31	3	fair
8	7	1	13	188	3	fair	6	1	1	6	26	2	poor	11	10	1	3	21	2	poor
9	8	–	12	312	3	poor	7	12	–	6	13	2	v.poor	12	9	–	2	35	3	poor
10	9	–	11	135	2	poor	8	8	–	5	21	2	poor	13	9	2	3	33	3	poor
11	7	–	10	65	2	poor	9	8	–	3	32	2	fair	14	10	2	5	35	1	fair
12	8	1	10	123	3	fair	10	8	2	5	19	2	poor	15	10	1	6	21	–	v.poor
13	9	1	8	65	3	poor	11	12	–	3	19	3	poor	17	9	2	6	72	2	fair
14	7	1	9	37	2	poor	12	9	1	4	18	3	poor	18	8	–	6	18	–	v.poor
15	2	1	9	36	3	fair	13	9	–	4	13	2	poor	19	9	2	7	51	3	fair
16	8	1	8	49	3	fair	14	8	1	6	35	3	poor	20	9	1	6	30	2	poor
17	10	1	8	47	2	poor	15	9	–	7	36	3	poor	21	9	1	7	70	2	fair
18	7	2	9	110	3	fair	16	3	–	5	30	2	poor	22	9	–	7	31	2	poor
19	8	2	11	165	4	fair	17	9	–	6	62	3	fair	23	9	1	7	80	3	poor
20	9	–	9	112	3	fair	18	9	2	6	50	2	fair	24	10	1	7	170	3	good
21	10	2	11	97	3	poor	19	9	1	7	31	2	poor	25	10	1	7	163	3	fair
22	9	–	9	85	3	poor	20	10	1	8	57	2	poor	26	10	2	8	90	2	poor
23	10	1	10	37	3	poor	21	10	1	8	46	2	poor	27	10	–	8	130	2	fair
24	8	–	10	55	3	poor	22	10	–	7	31	2	poor	28	2	–	8	68	2	poor
25	8	1	8	31	3	poor	24	9	–	7	45	1	poor	29	2	2	10	82	2	fair
26	8	–	10	35	3	poor	25	9	1	8	135	4	fair	31	2	2	9	64	4	poor
27	5	2	8	22	3	poor	26	9	–	6	57	1	poor							

SUNSPOT OBSERVATIONS,

MADE AT THE HAVERFORD COLLEGE OBSERVATORY WITH THE 8-INCH EQUATORIAL,

By W. H. COLLINS.

Date	Time	Groups	Spots	Fac. Groups	Def. and Size
1896 July 1	2	6	31	5	good ; 1 large
2	1	3	30	2	poor
3	12	4	31	2	good ; 2 large
4	9	3	18	1	poor ; 2 large
5	10	3	53	3	good ; 4 large
6	10	3	42	1	fair ; 3 large
7	9	5	47	2	poor ; 4 large
8	11	8	100	1	good ; 5 large
9	3	8	135	2	good ; 3 large
10	12	7	105	–	poor ; 12 large
11	8	8	127	1	fair ; 4 large
12	4	7	159	–	fine ; 9 large
13	10	7	97	2	fair ; 6 large
15	9	7	91	2	fair ; 3 large
16	4	5	87	1	good ; 2 large
17	10	5	110	–	fair ; 3 large
18	9	4	48	1	fair ; 3 large
19	9	5	55	2	good ; 3 large
20	10	6	31	1	bad ; 4 large
21	11	7	27	2	bad
22	9	6	54	3	fair ; 1 large
23	9	6	17	–	bad ; 2 large
24	2	7	26	2	poor ; 1 large
25	9	5	25	2	poor : 1 large
28	10	4	7	–	poor : 1 large
30	9	8	31	2	poor
31	11	6	19	2	good
Sept. 2	11	7	80	3	good ; 3 large
3	9	6	58	1	poor ; 4 large
4	10	6	96	3	good ; 4 large
5	9	5	100	1	fair ; 3 large
6	11	7	86	1	fair ; 1 large
7	9	8	100	3	fair ; 2 large
8	10	7	60	2	poor ; 1 large
9	2	2	50	–	bad ; 1 large
10	2	2	32	–	bad ; 2 large
11	2	4	50	–	bad : 2 large
12	12	5	57	1	good : 1 large
15	2	5	31	–	fair ; 2 large
16	11	5	34	1	good ; 1 large
17	9	5	29	–	poor
18	10	6	46	3	good
19	9	3	19	–	poor
20	9	6	34	1	good
21	9	7	28	2	poor
22	8	5	31	1	poor
24	9	7	52	1	fair
28	9	4	18	2	bad ; 1 large
29	10	5	52	1	good
30	9	6	50	–	poor
1896 Oct. 1	9	6	41	–	fair : 4 large
2	9	5	37	1	fair : 3 large
3	9	7	30	1	fair ; 1 large
7	9	6	20	1	fair
8	9	7	23	–	poor
9	10	4	28	1	good
10	11	6	26	–	poor
11	9	3	11	–	poor
12	10	4	22	1	poor
14	3	7	38	–	good : 1 large
15	3	6	56	1	good ; 1 large
17	10	5	42	–	fair ; 1 large
18	10	6	39	1	fair ; 2 large
19	10	7	85	1	good ; 4 large
20	10	9	84	2	good ; 1 large
24	3	11	106	1	good ; 5 large
25	9	9	76	2	fair ; 2 large
26	10	7	52	–	fair ; 4 large
28	10	6	73	–	fair ; 3 large
30	10	8	48	2	poor
31	10	4	17	1	poor
Nov. 1	9	4	25	1	fair
2	12	5	21	3	fair
6	10	4	9	–	poor
7	10	4	15	–	bad
10	9	7	63	1	poor ; 1 large
11	10	8	88	–	poor
14	10	7	125	2	poor
15	10	12	88	2	fair ; 2 large
16	10	10	84	1	fair ; 1 large
18	9	9	58	2	bad ; 2 large
20	10	6	117	2	fair
22	2	5	98	–	fair
24	12	5	71	1	fair
25	10	6	61	1	fair
26	1	3	48	–	poor
28	2	3	44	2	fair
Dec. 2	10	2	79	1	good
4	1	3	46	–	bad
6	11	2	37	1	fair ; 2 large
8	12	1	20	–	bad : 1 large
11	10	3	37	2	poor
18	10	9	70	2	fair ; 2 large
20	12	9	61	1	good ; 3 large
21	12	9	67	1	fair ; 3 large
23	3	8	131	1	good ; 3 large
27	12	7	153	3	fair ; 2 large

The observer was absent during August.

RECENT LATITUDE DETERMINATION AT THE SAYRE OBSERVATORY,

By C. L. DOOLITTLE.

The summary of latitude-values which follows is the result of a preliminary reduction of recent observations made at this place. It is thought advisable to publish these results now, as the more complete reduction which is in progress will not be completed for some weeks. This farther reduction will consist mainly in checking the computations (already done in part), and in a readjustment of the declinations. No material change is likely to follow, at least the character of the results is not likely to be affected by it.

The star-list employed is in the main the same as that used in the work of 1889–90. Of course the adjusted values of the declinations have been used, so that these results are practically homogeneous with the former. However, not all of the stars included in that list have been used, a number of badly situated pairs having been dropped. The vacant places have been filled with new pairs, but the latter are not included in this preliminary work.

	$\varphi = 40° 36' 20'' +$ $''$	Determinations
1892 Oct. 10 – Oct. 24	3.285	118
Oct. 30 – Nov. 17	3.214	97
Nov. 20 – Dec. 5	3.112	80
Dec. 10 – Dec. 26	3.071	97
Dec. 27 – Jan. 13	3.012	57
1893 Jan. 16 – Jan. 26	2.983	89
Feb. 3 – Feb. 16	3.038	85
Feb. 20 – Mar. 7	2.894	103
Mar. 13 – Mar. 21	3.068	48
Mar. 27 – April 4	2.888	103
1893 April 16 – April 28	2.931	70
May 6 – May 12	2.925	94
May 19 – June 8	3.070	80
June 9 – June 20	3.006	89
June 23 – June 30	3.057	57
July 2 – July 20	3.093	156
July 23 – Aug. 10	3.123	160
Sept. 2 – Sept. 21	3.201	151
Sept. 23 – Oct. 9	3.200	138
Oct. 14 – Oct. 30	3.230	103
Oct. 31 – Nov. 16	3.300	149
Nov. 26 – Dec. 13	3.300	118
Dec. 20 – Dec. 27	3.172	73
	Mean 3.097	Total 2315

The mean values given by former determinations are reproduced for purposes of comparison.

	° ′ ″	
1877.17	40 36 23.905	
1886.12	23.515	
1890.47	23.335	New star list
"	23.287	Old list*
1892 and 93	23.094	

The last is simply the mean of the individual values given above, and will differ slightly from the true mean value.

It is worthy of note that the progressive diminution appears to be still in progress. Whatever the explanation may be, I see no escape from the conclusion that the mean value of the latitude is now less than it was in 1877.

Bethlehem, Pa., 1894 *Feb.* 5.

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* See *A.J.* XII, 73, 76.

NEW ASTEROIDS.

Prof. KREUTZ communicates the discovery of two more asteroids, photographed by Mr. CHARLOIS on January 8, and one on January 10.

AQ	13^M	Jan. 8,	$9^h 54^m.0$ Nice M.T.	$\alpha = 7^h 21^m 48^s$,	$\delta = +20° 1'$.	Daily motion, -48^s in α, and $2'$ northward.
AR	13^M	8,	$9^h 54^m.0$ Nice M.T.	$\alpha = 7^h 36^m 12^s$,	$\delta = +24° 10'$.	Daily motion, -60^s in α, and $4'$ northward.
AS	$12\frac{1}{2}^M$	10,	$11^h 14^m.0$ Nice M.T.	$\alpha = 8^h 33^m 16^s$,	$\delta = +17° 42'$.	Daily motion, -44^s in α, and $6'$ northward.

Numbers have been assigned by the *Recheninstitut* to those discovered since 1893 Aug. 19, as follows:

AI	1893 Sept. 15	CHARLOIS.	(373)
AK	Sept. 18	"	(374)
AL	Sept. 18	"	(375)
AM	1893 Sept. 18	CHARLOIS.	(376)
AN	Sept. 20	"	(377)
AP	Dec. 6	"	(378)

CORRIGENDA.

No. 308, p. 167, the correction for 2266 should be —21, instead of —8; the correction for 2691 should be +12, instead of —12.

No. 310, p. 187, Table. The number for *V Orionis* should be 1805.

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CORRIGENDA.

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DOUBLE-STAR MEASURES,

BY WM. H. COLLINS.

The following double-star measures were made during the first half of the year 1893, by Mr GEORGE L. JONES, with a few exceptions. The ten-inch Clark Equatorial of the Haverford College Observatory was used, with a magnifying power of 375. Approximate places are for 1880.0.

β 398.

R.A. = $1^{h}\ 5^{m}$. Decl. = +47° 10′.

	p °	s ″	wt.	Mag.	Mag.	h	Obs'r
1893.060	52.5	1.73	2	9.2	9.2	3.6	J

Σ 535.

R.A. = $4^{h}\ 17^{m}$. Decl. = +11° 6′.

1893.060	330.3	1.92	2	7.2	8.2	4.2	J

Σ 572.

R.A. = $4^{h}\ 31^{m}$. Decl. = +26° 42′.

1893.200	21.0	3.38	2	7.0	7.2	6.8	J

So. 503.

R.A. = $5^{h}\ 49^{m}$. Decl. = +13° 56′.

1893 143	346.8	5.47	2	7.0	8.0	6.6	J
3.167	347.0	5.37	3	7.4	8.4	6.4	J
1893.155	346.9	5.42		7.2	8.2		

Σ 932.

R.A. = $6^{h}\ 28^{m}$. Decl. = +14° 50′.

1893.050	330.5	2.06	3	8.0	8.0	7.3	J
3.099	330.6	2.11	3	8.2	8.2	6.3	J
1893.074	330.6	2.08		8.1	8.1		

Σ 941.

R.A. = $6^{h}\ 30^{m}$. Decl. = +41° 41′.

1893.110	82.5	1.98	3	7.0	7.7	8.3	J
3.170	82.1	1.84	2	7.0	7.8	9.3	J
1893.140	82.3	1.91		7.0	7.8		

β 326.

R.A. = $6^{h}\ 49^{m}$. Decl. = +2° 28′.

1893.200	60.5	1.08	2	8.0	9.2	7.1	J

Σ 1037.

R.A. = $7^{h}\ 5^{m}$. Decl. = +27° 26′.

1893.060	307.5	1.25	3	7.4	7.6	4.5	J
3.110	307.5	1.13	2	7.6	8.0	9.1	J
1893.085	307.5	1.19		7.5	7.8		

Σ 1049.

R.A. = $7^{h}\ 8^{m}$. Decl. = −8° 44′.

	p °	s ″	wt.	Mag.	Mag.	h	Obs'r
1893.200	39.5	3.93	1	8.0	9.3	7.4	J

*O*Σ 170.

R.A. = $7^{h}\ 11^{m}$. Decl. = +9° 31′.

1893.110	112.7	1.26	3	7.5	7.7	7.8	J
3.143	113.7	1.28	3	7.5	7.7	6.9	J
3.200	112.4	1.37	2	8.0	8.2	7.8	J
1893.151	112.9	1.30		7.7	7.9		

Σ 1110.

R.A. = $7^{h}\ 27^{m}$. Decl. = +32° 9′.

1893.170	227.3	5.61	2	. .	. .	5.7	J

Σ 1126.

R.A. = $7^{h}\ 34^{m}$. Decl. = +5° 30′.

1893.110	143.8	1.20	2	7.3	7.6	7.3	J
3.143	144.7	1.21	2	7.2	7.6	7.2	J
1893.126	144.2	1.20		7.2	7.6		

*O*Σ 182.

R.A. = $7^{h}\ 46^{m}$. Decl. = +3° 42′.

1893.110	33.2	0.84	2	8.0	8.2	8.0	J
3.167	32.9	0.94	2	7.8	8.1	7.5	J
1893.138	33.0	0.89		7.9	8.1		

Σ 1157.

R.A. = $7^{h}\ 48^{m}$. Decl. = −2° 29′.

1893.050	245.9	1.00	3	8.0	8.0	7.8	J
3.100	246.1	1.16	2	8.0	8.0	7.8	J
1893.075	246.0	1.08		8.0	8.0		

Σ 1177.

R.A. = $7^{h}\ 58^{m}$. Decl. = +27° 52′.

1893.200	350.2	3.73	3	7.0	7.4	6.5	J
3.238	350.8	3.51	2	7.0	7.6	9.7	J
1893.219	350.5	3.62		7.0	7.5		

Σ 1187.

R.A. = $8^{h}\ 2^{m}$. Decl. = +32° 34′.

1893.181	47.2	1.87	2	7.2	8.2	9.7	J
3.184	47.5	1.94	3	7.0	7.8	10.0	J
1893.182	47.4	1.90		7.1	8.0		

Σ 1196.

R.A. = $8^h\ 5^m$. Decl. = +18° 1′.

A AND B.

	p °	s ″	wt.	Mag.	Mag.	h	Obs'r
1893.143	26.9	1.07	3	5.0	6.0	8.1	J
3.167	26.0	1.14	2	5.0	5.8	7.3	J
1893.155	26.4	1.10		5.0	5.9		

$\frac{1}{2}(A+B) : C.$

1893.143	115.8	5.39	2	5.0	6.4	8.2	J
3.167	115.6	5.25	2	5.0	6.0	7.2	J
1893.155	115.7	5.32		5.0	6.2		

β 905.

R.A. = $8^h\ 11^m$. Decl. = −15° 57′.

1893.200	12.1	3.76	1	8.0	10.0	8.5	J

Σ 1244.

R.A. = $8^h\ 30^m$. Decl. = +42° 13′.

1893.181	0.4	3.74	2	8.0	9.0	10.4	J
3.184	0.9	3.74	2	8.2	9.6	10.6	J
1893.182	0.6	3.74		8.1	9.3		

β 207.

R.A. = $8^h\ 34^m$. Decl. = −19° 19′.

1893.200	102.0	4.27	2	7.0	10.5	8.6	J
3.208	101.3	4.42	2	7.5	10.5	8.6	J
1893.204	101.6	4.34		7.2	10.5		

Σ 1263.

R.A. = $8^h\ 37^m$. Decl. = +42° 8′.

1893.184	19.9	50.31	3	7.8	8.2	10.6	J
3.238	19.6	50.35	2	8.2	8.5	10.4	J
1893.211	19.8	50.33		8.0	8.4		

Σ 1273.

R.A. = $8^h\ 40^m$. Decl. = +6° 52′.

1893.050	228.7	3.51	3	3.8	7.8	8.4	J
3.110	229.2	3.46	2	4.2	8.0	8.0	J
3.184	229.3	3.36	2	4.0	8.0	8.8	J
1893.115	229.1	3.44		4.0	7.9		

Σ 1291.

R.A. = $8^h\ 47^m$. Decl. = +31° 2′.

1893.181	326.5	1.59	2	6.3	6.3	10.2	J
3.184	327.1	1.64	3	6.0	6.2	10.3	J
1893.182	326.8	1.62		6.2	6.2		

β 24.

R.A. = $8^h\ 48^m$. Decl. = −8° 18′.

1893.200	178.0	1.07	1	8.0	8.8	8.8	J
3.241	176.8	1.04	2	8.0	8.6	8.7	J
1893.220	177.4	1.06		8.0	8.7		

Σ 1295.

R.A. = $8^h\ 50^m$. Decl. = −7° 31′.

1893.200	359.1	4.28	3	7.0	7.2	8.9	J
3.208	359.1	4.32	2	7.0	7.0	8.8	J
1893.204	359.1	4.30		7.0	7.1		

β 210.

R.A. = $8^h\ 51^m$. Decl. = −16° 58′.

	p °	s ″	wt.	Mag.	Mag.	h	Obs'r
1893.200	183.4	2.69	2	6.5	6.5	9.2	J
3.208	182.7	2.63	2	7.2	7.2	8.9	J
1893.204	183.0	2.66		6.8	6.8		

Σ 1300.

R.A. = $8^h\ 55^m$. Decl. = +15° 45′.

1893.170	197.9	4.85	2	8.8	9.0	8.2	J
3.181	198.0	4.71	1	9.0	9.0	8.8	J
1893.176	198.0	4.78		8.9	9.0		

Σ 1316.

R.A. = $9^h\ 2^m$. Decl. = −6° 39′.

A AND B.

1893.184	143.3	6.40	1	8.0	10.6	9.3	J

A. AND C.

1893.184	167.6	7.40	2	8.0	10.2	9.3	J

B AND C.

1893.184	51.1	3.60	1	. .	. .	9.5	J

Σ 1343.

R.A. = $9^h\ 14^m$. Decl. = +5° 31′.

1893.241	270.6	9.93	1	9.0	9.2	8.9	J
3.244	271.4	9.93	3	8.8	9.2	10.0	J
1893.242	271.0	9.93		8.9	9.2		

β 338.

R.A. = $9^h\ 17^m$. Decl. = −14° 59 .

1893.241	274.0	7.19	2	9.0	10.2	7.4	J
3.244	274.4	7.28	2	9.0	10.8	9.6	J
1893.242	274.2	7.24		9.0	10.5		

Σ 1348.

R.A. = $9^h\ 18^m$. Decl. = +6° 52′.

1893.181	325.7	1.81	2	7.5	7.7	9.2	J
3.184	325.8	1.86	3	7.5	7.7	9.0	J
3.244	324.2	1.52	3	7.3	7.4	10.3	J
1893.203	325.2	1.73		7.4	7.6		

Σ 1355.

R.A. = $9^h\ 21^m$. Decl. = +6° 46′.

1893.241	333.7	2.55	2	7.0	7.1	9.2	J
3.244	335.0	2.47	2	7.0	7.0	10.4	J
1893.242	334.4	2.51		7.0	7.0		

β 910.

R.A. = $9^h\ 27^m$. Decl. = −13° 28′.

1893.200	305.2	6.51	2	7.5	10.5	9.2	J
3.244	304.9	6.15	2	7.2	10.2	9.8	J
1893.222	305.0	6.33		7.4	10.4		

Σ 1389.

R.A. = $9^h\ 46^m$. Decl. = +27° 33′.

1893.148	312.0	2.02	1	8.2	8.8	7.5	J
3.170	312.9	1.98	2	8.2	8.8	8.4	J
1893.159	312.4	2.00		8.2	8.8		

Σ 1417.

R.A. = $10^h\ 9^m$. Decl. = +19° 43′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
	°	″					
1893.200	262.7	2.43	2	8.3	8.5	8.1	J
3.238	262.1	2.29	2	8.3	8.5	9.4	J
1893.219	262.4	2.36		8.3	8.5		

OΣ 215.

R.A. = $10^h\ 10^m$. Decl. = +18° 20′.

1893.244	215.4	0.78	2	7.0	7.0	11.8	J
3.364	212.9	0.78	2	7.0	7.3	11.5	J
1893.304	214.2	0.78		7.0	7.2		

Σ 1426.

R.A. = $10^h\ 14^m$. Decl. = +7° 2′.

A AND B.

1893.241	278.6	0.85	1	8.0	8.3	10.3	J
3.244	278.8	0.86	2	8.0	8.2	10.6	J
1893.242	278.7	0.86		8.0	8.2		

½(A+B) : C.

1893.241	8.4	7.59	1	8.0	10.2	10.4	J
3.244	7.7	7.61	3	8.0	10.0	10.7	J
1893.242	8.0	7.60		8.0	10.1		

Σ 1424.

R.A. = $10^h\ 13^m$. Decl. = +20° 27′.

1893.397	115.5	3.31	2	2.3	3.8	9.9	J
3.400	115.5	3.29	1	. .	. .	8.0	J
1893.398	115.5	3.30		2.3	3.8		
1893.361	116.0	3.31	3	2.0	4.0	12.0	C
3.438	115.2	3.73	2	. .	. .	14.8	C
3.482	115.4	3.62	2	. .	. .	15.2	C
1893.427	115.5	3.55					

Σ 1450.

R.A. = $10^h\ 29^m$. Decl. = +9° 16′.

1893.143	160.2	2.38	2	6.0	8.5	9.8	J
3.159	160.4	2.46	1	5.8	8.8	10.8	J
3.241	159.6	2.18	2	6.0	8.5	10.2	J
1893.181	160.1	2.34		5.9	8.6		

Σ 1457.

R.A. = $10^h\ 32^m$. Decl. = +6° 21′.

1893.110	319.8	1.32	1	7.2	8.2	9.3	J
3.143	321.6	1.13	2	7.3	7.8	10.3	J
1893.126	320.7	1.22		7.2	8.0		

Σ 1487.

R.A. = $10^h\ 49^m$. Decl. = +25° 23′.

1893.143	107.3	6.52	3	5.0	7.0	9.7	J
3.170	105.8	6.46	3	5.0	7.0	9.7	J
3.241	105.6	6.50	2	5.0	7.2	10.0	J
1893.185	106.2	6.49		5.0	7.1		

Σ 1516.

R.A. = $11^h\ 7^m$. Decl. = +74° 7′.

1893.414	96.8	16.43	1	7.0	7.0	13.3	J
3.416	96.9	16.43	2	7.0	7.2	12.9	J
1893.415	96.8	16.43		7.0	7.1		

β 220.

R.A. = $11^h\ 7^m$. Decl. = −17° 51′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
	°	″					
1893.364	141.1	0.62	1	6.2	6.6	12.0	J
3.397	139.5	0.71	1	6.2	6.6	12.0	J
1893.380	140.3	0.66		6.2	6.6		

Σ 1523.

R.A. = $11^h\ 12^m$. Decl. = +32° 12′.

1893.044	194.3	2.03	2	5.2	5.8	13.5	J
3.050	193.4	1.98	2	5.4	6.0	9.0	J
3.143	192.6	2.05	2	4.8	5.4	9.0	J
1893.079	193.4	2.02		5.1	5.7		
1893.362	189.7	1.98	3	5.0	5.0	12.5	C
3.438	187.5	1.95	2	. .	. .	15.1	C
3.482	186.4	1.93	2	. .	. .	16.2	C
1893.427	187.9	1.95		5.0	5.0		

Σ 1527.

R.A. = $11^h\ 13^m$. Decl. = +14° 56′.

1893.162	15.1	3.83	2	7.0	8.0	11.4	J
3.184	14.9	3.64	2	7.0	7.8	11.3	J
3.241	14.6	3.33	2	6.6	7.4	10.7	J
1893.196	14.9	3.60		6.9	7.7		

Σ 1536.

R.A. = $11^h\ 18^m$. Decl. = +11° 11′.

1893.241	56.7	2.58	2	4.8	7.8	10.8	J
3.244	56.6	2.56	3	5.0	7.8	12.0	J
3.348	56 5	2.67	1	5.0	7.8	12.1	J
1893.278	56.6	2.60		4.9	7.8		

OΣ 225.

R.A. = $11^h\ 26^m$. Decl. = +61° 45′.

1893.170	87.0	0.95	2	6.0	7.2	9.2	J
3.241	87.7	1.25	1	5.8	7.2	8.5	J
1893.206	87.4	1.10		5.9	7.2		

Σ 1552.

R.A. = $11^h\ 28^m$. Decl. = +17° 28′.

A AND B.

1893.159	210.0	3.67	2	6.5	7.5	11.8	J
3.170	210.0	3.22	3	6.8	7.8	10.3	J
3.238	210.0	3.19	3	6.8	7.8	10.0	J
1893.189	210.0	3.36		6.7	7.7		

A AND C.

1893.170	234.6	63.40	1	6.8	9.2	10.5	J

Σ 1596.

R.A. = $11^h\ 58^m$. Decl. = +22° 8′

1893.159	238.2	4.00	1	6.2	7.2	12.4	J
3.238	239.2	3.86	3	7.0	8.0	10.2	J
1893.198	238 7	3.93		6.6	7.6		

Σ 1647.

R.A. = $12^h\ 24^m$. Decl. = +10° 23′.

1893.044	219.2	1.21	2	7.5	8.0	13.0	J
3.353	218.8	1.21	1	7.2	7.6	12.7	J
1893.198	219.0	1.21		7.4	7.8		

Σ 1658.

R.A. = $12^{h}\ 29^{m}$. Decl. = +8° 7′.

A AND B.

	p °	s ″	wt.	Mag.	Mag.	h	Obs'r
1893.159	354.9	2.16	1	7.8	9.8	12.2	J
3.184	354.8	2.34	3	8.0	9.6	11.8	J
1893.172	354.8	2.25		7.9	9.7		

A AND C.

1893.184	259.3	106.82	3	8.0	8.6	11.8	J

Σ 1670.

R.A. = $12^{h}\ 36^{m}$. Decl. = −0° 47′.

1893.362	152.0	5.84	3	. .	. .	12.8	C
3.482	151.4	5.63	2	. .	. .	15.8	C
1893.422	151.7	5.74					

O.S. 73.

R.A. = $12^{h}\ 52^{m}$. Decl. = −12° 29′.

1893.364	65.5	2.18	1	8.0	8.2	13.1	J
3.384	66.0	1.78	1	8.5	8.7	12.9	J
1893.374	65.8	1.98		8.2	8.4		

β 928.

R.A. = $12^{h}\ 57^{m}$. Decl. = −5° 57′.

1893.364	313.5	2.08	1	8.0	9.0	13.3	J
3.384	314.1	1.94	1	8.3	9.5	13.1	J
1893.374	313.8	2.01		8.2	9.2		

*O*Σ 261.

R.A. = $13^{h}\ 6^{m}$. Decl. = +32° 43′.

1893.244	342.8	1.20	3	6.5	6.8	10.9	J
3.348	343.4	1.14	1	7.0	7.3	11.5	J
1893.296	343.1	1.17		6.8	7.0		

β 342.

R.A. = $13^{h}\ 9^{m}$. Decl. = −18° 17′.

1893.364	33.1	4.84	2	8.0	8.4	13.6	J
3.384	32.8	4.84	1	8.2	8.4	13.3	J
1893.374	33.0	4.84		8.1	8.4		

Σ 1734.

R.A. = $13^{h}\ 15^{m}$. Decl. = +3° 34′.

1893.342	189.9	1.19	1	7.3	7.7	13.7	J
3.353	188.9	1.17	1	7.0	7.2	12.9	J
1893.348	189.4	1.18		7.2	7.4		

Σ 1742.

R.A. = $13^{h}\ 18^{m}$. Decl. = +2° 2′.

1893.348	350.2	1.09	1	7.3	7.5	13.0	J
3.353	351.1	1.16	1	7.3	7.8	13.1	J
1893.350	350.6	1.12		7.3	7.6		

Σ 1757.

R.A. = $13^{h}\ 28^{m}$. Decl. = +0° 18′.

1893.362	74.7	2.38	2	8.5	9.5	13.2	C
1893.159	73.8	2.81	1	8.0	9.0	13.1	J
3.307	74.4	2.73	1	8.0	8.6	14.1	J
1893.233	74.1	2.77		8.0	8.8		

β 114.

R.A. = $13^{h}\ 28^{m}$. Decl. = −8° 0′.

	p °	s ″	wt.	Mag.	Mag.	h	Obs'r
1893.364	140.9	1.43	1	8.0	8.2	13.9	J
3.375	140.5	1.39	1	8.2	8.4	14.5	J
1893.370	140.7	1.41		8.1	8.3		

Σ 1768.

R.A. = $13^{h}\ 32^{m}$. Decl. = +36° 54′.

1893.397	133.4	0.83	2	5.5	8.2	15.3	J

Σ 1777.

R.A. = $13^{h}\ 37^{m}$. Decl. = +4° 9′.

1893.384	232.4	3.43	2	6.0	8.2	13.6	J

Σ 1785.

R.A. = $13^{h}\ 44^{m}$. Decl. = +27° 35′.

1893.159	249.3	1.85	2	7.5	8.0	15.8	J
3.348	250.8	1.47	1	7.2	7.8	11.8	J
3.353	250.9	1.46	1	7.2	7.6	12.4	J
3.359	250.8	1.36	2	7.2	7.5	14.7	J
1893.306	250.4	1.54		7.3	7.7		

Σ 1788.

R.A. = $13^{h}\ 49^{m}$. Decl. = −7° 28′.

1893.348	76.1	2.78	1	7.0	7.8	13.2	J
3.353	75.9	2.69	1	7.0	7.8	13.3	J
1893.350	76.0	2.74					

HOLDEN 16.

R.A. = $14^{h}\ 2^{m}$. Decl. = −2° 58′.

1893.384	215.7	2.37	1	8.2	8.4	13.9	J

β 803.

R.A. = $14^{h}\ 5^{m}$. Decl. = −2° 6 .

1893.384	240.1	4.78	1	8.5	11.0	14.2	J

Σ 1819.

R.A. = $14^{h}\ 9^{m}$. Decl. = +3° 41′.

1893.044	184.0	1.38	2	7.8	8.0	14.0	J
3.326	184.8	1.28	1	7.7	7.9	14.1	J
1893.185	184.4	1.33		7.8	8.0		

β 116.

R.A. = $14^{h}\ 13^{m}$. Decl. = −13° 9′.

1893.384	276.5	3.08	1	7.8	8.0	14.4	J

Σ 1888.

R.A. = $14^{h}\ 46^{m}$. Decl. = +19° 36′.

1893.159	238.9	3.42	2	4.4	7.0	15.4	J
3.326	238.3	3.15	1	5.0	7.5	14.3	J
3.359	238.2	3.17	1	5.2	7.0	13.9	J
1893.281	238.5	3.25		4.9	7.2		
1893.362	232.2	3.33	2	5.0	7.0	13.8	C
3.526	233.7	2.99	2	. .	. .	17.7	C
1893.444	233.0	3.16		5.0	7.0		

Σ 1909.

R.A. = $15^{h}\ 0^{m}$. Decl. = +48° 7′.

1893.044	242.4	4.96	3	5.2	6.2	11.6	J
3.348	242.3	4.78	2	5.0	6.0	12.6	J
1893.196	242.4	4.87		5.1	6.1		

	p	s	wt.	Mag.	Mag.	h	Obs'r
	°	″					
1893.362	240.4	4.85	1	5.0	6.0	13.5	C
3.526	241.4	4.63	2	. .	. .	18.2	C
1893.444	240.9	4.74		5.0	6.0		

Σ 1910.

R.A. = 15^h 2^m. Decl. = +9° 41′.

1893.159	31.0	4.68	2	7.0	7.0	15.1	J
3.359	30.9	4.60	2	7.0	7.0	14.5	J
1893.259	31.0	4.64		7.0	7.0		

HOLDEN 23.

R.A. = 15^h 3^m. Decl. = −7° 48′.

1893.384	357.0	3.34	1	9.2	9.4	14.8	J

Σ 1937.

R.A. = 15^h 18^m. Decl. = +30° 43′.

1893.397	243.4	0.59	2	6.0	6.5	17.3	J

Σ 1938.

R.A. = 15^h 20^m. Decl. = +37° 46′.

1893.397	87.2	1.06	2	7.2	7.5	17.8	J

*O*Σ 298.

R. A = 15^h 32^m. Decl. = +40° 13′.

1893.397	171.7	0.94	2	7.0	7.3	18.1	J

Σ 1985.

R.A. = 15^h 50^m. Decl. = −1° 49′.

1893.159	334.4	5.77	1	7.0	8.2	16.2	J
3.397	335.2	5.91	3	7.0	8.0	16.5	J
1893.278	334.8	5.84		7.0	8.1		

Σ 1998.

R.A. = 15^h 58^m. Decl. = −11° 2′.

A AND B.

1893.397	27.5	1.17	3	5.9	5.2	15.9	J
3.452	28.7	1.13	1	5.0	5.3	16.2	J
1893.424	28.1	1.15		5.0	5.2		

½(A+B) : C.

1893.397	61.6	7.61	2	. .	8.0	15.9	J
3.452	61.8	7.56	1	. .	8.0	16.2	J
1893.424	61.7	7.58		. .	8.0		

Σ 2021.

R.A. = 16^h 8^m. Decl. = +13° 51′.

1893.159	332.2	4.12	2	7.0	7.0	16.5	J
3.397	332.6	3.85	3	7.0	7.0	16.8	J
1893.278	332.4	3.98		7.0	7.0		

Σ 2032.

R.A. = 16^h 10^m. Decl. = +34° 10′.

A AND B.

1893.326	209.9	4.30	1	5.2	6.2	14.6	J
3.359	209.3	4.30	1	5.0	6.8	14.3	J
3.414	209.5	4.28	2	5.0	6.0	14.3	J
1893.366	209.6	4.29		5.1	6.3		
1893.362	209.0	4.24	2	5.2	6.3	14.2	C
3.526	208.8	4.09	2	. .	. .	18.7	C
1893.444	208.9	4.16		5.2	6.3		

A AND C.

	p	s	wt.	Mag.	Mag.	h	Obs'r
	°	″					
1893.414	86.5	60.02	1	. .	10.5	14.6	J

Σ 2055.

R.A. = 16^h 25^m. Decl. = +2° 15′.

1893.159	43.6	1.68	2	4.0	5.7	16.8	J
3.397	44.6	1.64	2	4 5	5.7	16.2	J
1893.278	44.1	1.66		4.2	5.7		

Σ 2084.

R.A. = 16^h 37^m. Decl. = +31° 49 .

1893.526	49.5	1.24	2	. .	. .	18 9	C

Σ 2120.

R.A. = 17^h 0^m. Decl. = +28° 15′.

1893.414	246.9	6.66	2	7.2	9.2	15.7	J
3.452	247.4	6.70	2	7.4	9.2	15.4	J
1893.433	247.1	6.68		7.3	9.2		

Σ 2130.

R.A. = 17^h 3^m. Decl. = +54° 38′.

1893.414	154.8	2.59	1	5.0	5.2	15.0	J
1893.526	155.0	2.35	2	. .	. .	19.2	C

Σ 3127.

R.A. = 17^h 10^m. Decl. = +24° 59′.

1893.414	188.7	15.54	2	3.0	8.0	15.3	J
3.452	189.2	15.64	2	3.0	8.0	15.7	J
1893.433	189.0	15.59		3.0	8.0		

Σ 2173.

R.A. = 17^h 24^m. Decl. = −0° 58′.

1893.438	338.8	1.13	1	6.0	6.2	17.5	J

Σ 2272.

R.A. = 17^h 59^m. Decl. = +2° 33′.

1893.551	312.0	2.46	. .	. .	. .	19.3	C
3.564	315.0	2.16	. .	. .		. .	C
1893.558	313.5	2.31					

Σ 2471.

R.A. = 19^h 5^m. Decl. = +7° 56′.

1893.449	124.6	7.87	1	7.8	11.5	19.2	J

*O*Σ 388.

R.A. = 19^h 47^m. Decl. = +25° 33′.

1893.449	139.8	3.83	2	8.2	8.4	18.8	J
3.466	140.5	3.80	1	8.0	8.2	21.9	J
1893.458	140 2	3.81		8.1	8.3		

Σ 2749.

R.A. = 20^h 59^m. Decl. = +3° 3′.

A : ½(B+C).

1893.449	155.4	2.53	1	8.0	9.5	20.8	J
3.466	159.1			8.0	9.+	21.3	J
1893.458	157.2	2.53		8.0	9.+		

B AND C.

1893.449	155.1	1.24	1	9.5	9.7	20.8	J
3.466	157.7	. .	. .	9.+	9.+	21.3	J
1893.458	156.4	1.24		9.+	9.+		

Σ 2760.

R.A. = 21h 2m. Decl. = +33° 39′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
	°	″					
1893.449	226.2	7.08	2	8.0	8.5	19.4	J

Σ 2804.

R.A. = 21h 27m. Decl. = +20° 11′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1893.449	331.5	2.91	1	7.4	7.7	19.8	J

Σ 2895.

R.A. = 22h 15m. Decl. = +24° 21′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1893.449	32.3	7.41	2	8.0	10.5	20.2	J

Σ 2909.

R.A. = 22h 23m. Decl. = −0° 38′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
	°	″					
1893.449	323.6	3.22	2	4.0	4.0	22.0	J
3.466	323.9	3.17	1	4.0	4.0	22.4	J
1893.458	323.8	3.20		4.0	4 0		

OΣ 500.

R.A. = 23h 32m. Decl. = +43° 46′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1893.449	324.0	0.78	1	6.0	7.0	21.4	J
3.466	324.0	0.70	1	6.0	7.0	21.6	J
1893.458	324.0	0.74		6.0	7.0		

Σ 3050.

R.A. = 23h 53m. Decl. = +33° 4′.

	p	s	wt.	Mag.	Mag.	h	Obs'r
1893.449	210.5	2.51	2	6.0	6.0	21.7	J

Haverford College, 1894 *February*.

THE LICK OBSERVATIONS OF COMET 1892 V,

By E. E. BARNARD.

I was much surprised to see in *A.J.* 310 the Lick observations come out so discordantly, as shown in Prof. PORTER's paper on Comet 1892 V. These observations were made by me, and I supposed they were good, so far as observations of a comet of this class would permit.

I have carefully gone over my observations, and find no errors of reduction, and in the main I cannot account for the discordances. I should expect to measure the position of an object like this to within 2″ or 3″ at the outside.

Following is the method I have used in observing comets. Our micrometer has only two wires — parallel. These are conveniently illuminated by an oil lamp, being the method of illumination used by Mr. BURNHAM in all his double-star work. Usually, the parallel being first determined, the difference of declination is measured, the telescope remaining stationary; three settings are made thus. The wires are then turned 90° by the position circle, and eight or ten transits taken over the set of two wires; the micrometer is then turned to the parallel again, and three more bisections in declination made. In general, the mean of the times for $\Delta\delta$ agrees with the mean of the times for the $\Delta\alpha$; if they differ by a sensible amount one or the other of these quantities is corrected for the motion of the comet. Some times when the comet is conveniently close to the star the $\Delta\alpha$ is measured directly.

As a check on my $\Delta\delta$, the wires are left as they were at the last bisection, when the transits are taken, and from the interval t over the wires we have $\left(\frac{15 \cos\delta}{r}\right) t = n$, the number of revolutions of the screw separating the wires at the last setting for $\Delta\delta$. One revolution $= r = 14''.059$. Out of the 12 observations of this comet, in all but three the $\Delta\alpha$ was measured direct, and the customary check was not secured.

The circle on the micrometer-head reads to 30 revolutions. When the readings are near 15, one has to be careful not to take the wrong side in applying the zero-reading.

Possibly, from the following, some light may be thrown on the measures. The times are in Mt. Hamilton M.T.

Oct. 13 7h 7m 41s $\Delta\delta$ +1′ 20″.0 (2)
7 16 42 $\Delta\delta$ +1 8 .0 (3)

The difference between these measures is 12″.0, while from Prof. PORTER's ephemeris the motion of the comet in that time should be 8″.9, a disagreement not greater than would be expected. An increase of the $\Delta\delta$ by 1 revolution of the screw would do away with the large discrepancy in the declination on this date, but it does not seem warranted by the records.

Oct. 16 10h 15m 19s $\Delta\delta$ = −3′ 33″.2 (2)
10 25 57 $\Delta\delta$ = −3 35 .8 (2)

The difference between these is 2″.6. The motion of the comet was 9″.9. The readings are clearly recorded. Diminishing the record by 1 revolution here would do away with the discrepancy. But it does not seem warranted.

Oct. 17 10h 27m 59s $\Delta\delta$ = −0′ 5″.6 (2)
10 49 41 $\Delta\delta$ = −0 49 .4 (2)

The first of these is certainly correct, for I estimated the comet to be 4″ south of star. The other seems too large, the difference being 43″.8, while the motion of the comet was 20″.2 only. Reducing the last $\Delta\delta$ by 1 revolution would remove the discrepancy with reference to the ephemeris.

Oct. 18 6h 44m 29s $\Delta\delta$ = +2′ 39″.8 (3)

Diminishing by the value of 1 revolution will do away with the discrepancy; but there is nothing to warrant it in the record.

Oct. 19. By a clerical error the $\Delta\delta$ was given +8′ 30″.6, instead of +7′ 30″.6.

Oct. 22. The recorded measures for $\Delta\delta$ are clear; and will justify no other interpretation, though, if we diminish the readings by 1 revolution, the discrepancy disappears. Both at the observations for $\Delta\delta$ and $\Delta\alpha$ the comet was most excessively faint; observations could not be made until the visitors left.

Oct. 24. The records for both stars are clear, and there does not seem to be any other interpretation. The measures for the $\Delta\alpha$ with the second star are discordant.

Oct. 25 $7^h\ 43^m\ 36^s$ $\Delta\alpha = -3'\ 14''.9$ (2)
7 57 27 $\Delta\alpha = -3\ 18\ .0$ (2)

If the $\Delta\alpha$ were diminished by 1 revolution, it would accord more nearly with the ephemeris. But the record is clear.

Nov. 21 $6^h\ 29^m\ 8^s$ $\Delta\delta = +2'\ 24''.6$ (2)
6 46 46 $\Delta\delta = +2\ 23\ .9$ (3)

On this date my notes say, "Comet most excessively faint. Only the vaguest traces of it." I see nothing to change in the observations, though the last set is very discordant. Of course a change of 1 revolution here would also make accord.

It is probable that I may have in general selected a different point in the comet to observe from the other observers, though this seems improbable, as there was no definite point to measure.

The coincidence of the wires was determined at the time of the observations.

On Oct. 15, the $\Delta\alpha$ should read $+0^m\ 11^s.05$, instead of $+0^m\ 10^s.80$.

Mt. Hamilton, 1894 *Feb.* 7.

OBSERVED MINIMA OF *Y CYGNI*, 1893,

BY PAUL S. YENDELL.

I have had the good fortune to secure observations of *Y Cygni* on twenty-six dates during the past season; from these observations twenty-five minima are deduced, and on the remaining evening the observations show no decided minimum.

Every precaution has been taken during these observations to avoid the influence of preconceived ideas: only the days of minima have been entered on my working ephemeris; after July 20 no examination of the observations was made until the whole series of minima had been observed; and on nearly or quite every evening on which the star was observed, the observations have been roughly checked by frequent examination with the field-glass, in which on dark nights it is quite faint when near the minimum, and in moonlight it disappears.

In spite of these precautions, it is feared that the minima observed on epochs 1628 and 1651, although apparently well-observed, were so far vitiated from this cause that a nominal weight only has been assigned to them.

The variation of the light-curve has been quite evident, as will be seen by the observed least magnitudes, given in the list below; on this account the minima have all been reduced graphically, by the single light-curves, and no attempt at the employment or formation of a mean light-curve has been made.

In the subjoined table, the residuals in the column O—C are obtained by comparison with Dunér's elements, as given in Chandler's Second Catalogue, the z term of $\pm 2^s.2$ being omitted.

Observed Minima.

E	Local Mean Time.	w	O—C	Least obs brightness	E	Local Mean Time	w	O—C	Least obs brightness
	h m		m	M		m h		m	M
1562	1893 May 6 12 39	2	+ 90.5	7.84	1648	1893 Sept. 12 8 34	4	+ 82.9	8.20
1570	18 11 38	4	+ 55.3	7.84	1649	13 12 35	4	—188.4	8.20
1598	June 29 10 14	3	+ 59.7	7.84	1651	16 11 44	1:	—232.6	8.25
1612	July 20 9 49	3	+ 62.7	8.00	1666	Oct. 9 7 38	2	+ 61.2	8.20
1623	Aug. 5 13 53	4	—179.1	8.33	1668	12 8 3	4	+ 91.2	8.32
1625	8 13 38	4	—188.5	8.25	1670	15 8 24	3	+117.4	8.32
1626	10 10 6	2	+117.4	8.08	1672	18 7 50	3	+ 88.4	8.16
1628	13 10 48	1:	+164.7	8.30	1674	21 7 55	4	+ 98.4	8.25
1634	22 9 46	4	+118.5	8.30	1677	25 11 37	4	—212.2	8.32
1636	25 9 54	4	+131.7	8.30	1679	28 11 18	2	—216.1	8.16
1637	26 13 25	3	—190.1	8.35	1682	Nov. 2 6 57	2	+ 60.3	8.20
1644	Sept. 6 9 13	4	+111.5	8.25	1688	11 6 53	3	+ 70.9	8.25
1646	9 8 38	4	+ 81.8	8.17					

On the evening of May 24, the star was watched from $9^h\ 15^m$ to $12^h\ 15^m$, without any definite minimum phase being detected, as although one observation at $11^h\ 13^m$ gave a magnitude of 7.8, this was only two steps below the highest observed light, and one step below the average of all the evening's observations.

Dorchester, Mass., 1894 *January* 4.

The large residuals shown by these observations appear to indicate either the need of considerable modification in the constants of Dunér's elements, or that, as suspected by him (*A.J.* Vol. XII, p. 3), the term z may be variable; but the evidence hitherto collected does not appear to furnish sufficient data to decide the matter.

OBSERVATIONS OF COMET *c* 1893 (*BROOKS*),

MADE AT THE OBSERVATORY OF THE STATE UNIVERSITY OF MISSOURI,

BY MILTON UPDEGRAFF.

1893 Columbia M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Nov. 9 16 33 58.3	1	3	+2 18.37	+2 13.3	12 59 52.13	+30 53 20.4	*n*9.717	0.597
17 13 55.9	2	6	+2 38.63	—0 57.7	12 59 55.12	+30 54 43.2	*n*9.692	0.524
10 16 51 44.3	3	9	—1 39.36	+0 22.8	13 1 57.3	+31 45.4	*n*9.710	0.553
12 17 3 47.3	4	6	+4 46.88	+2 5.0	13 6 18.2	+33 38.2	*n*9.708	0.501
14 17 8 55.3	5	7	+3 1.17	+5 50.0	13 10 53.03	+35 32 42.9	*n*9.712	0.456
15 16 33 19.0	6	5	+2 0.50	+3 43.4	13 13 13.21	+36 30 57.4	*n*9.728	0.476
18 17 17 53.6	7	6	+4 12.98	+5 53.9	13 20 58.09	+39 32 2.3	*n*9.721	0.344
19 17 10 5.1	8	5	—5 6.70	+4 57.8	13 23 39.66	+40 33 31.0	*n*9.734	0.346

Mean Places for 1893.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	12 57 32.57	+1.19	+30 51 24.7	—17.6	W.B XII, 1107
2	12 57 15.30	+1.19	+30 55 58.5	—17.6	W.B. XII, 1099
3	13 3 35.5	+1.17	+31 45.2	—18.0	DM. +31°2454
4	13 1 30.1	+1.23	+33 36.4	—19.2	DM. +33°2301
5	13 7 50.65	+1.21	+35 27 13.0	—20.1	Lalande 24555
6	13 11 11.51	+1.20	+36 27 34.2	—20.6	W.B. XIII, 173
7	13 16 43.93	+1.18	+39 26 30.4	—22.0	W.B. XIII, 286
8	13 28 45.28	+1.08	+40 28 55.3	—22.1	W.B. XIII, 542, 543, mean

NEW ASTEROIDS.

From Prof. Kreutz we have notice of the photographic discovery of two asteroids by Charlois, at Nice.

AT 12^M Jan. 29, $9^h\ 55^m.0$ Nice M.T. $\alpha = 8^h\ 44^m\ 56^s$, $\delta = +19°\ 24'$. Daily motion, -48^s in α, and 2′ northward.
AU 13^M 29, $9^h\ 55^m.0$ Nice M.T. $\alpha = 8^h\ 54^m\ 12^s$, $\delta = +19°\ 56'$. Daily motion, -48^s in α, and 3′ northward.

Dr. H. C. Wilson of Northfield, Minn., while examining a photograph of the *Pleiades*, taken with the 8-inch telescope of Carleton College, and four hours' exposure, found upon it two asteroid trails.

After photographing the region anew on Feb. 1 and 3, and calculating the positions of sundry asteroids from their orbits given in the *Berliner Jahrbuch*, he arrived at the conclusion that one of the trails was probably due to a previously unknown body of 12^M.

Measurements upon the plates gave for this the approximate places (Greenw. M.T),

Jan. 30.6494 $3^h\ 41^m\ 24^s.6$ $+24°\ 50'\ 29''$ | Feb. 3.6130 $3^h\ 44^m\ 17^s.2$ $+24°\ 54'\ 43''$

These positions were forwarded to Mr. Ritchie, and transmitted through his agency to Mr. Berberich of the Berlin *Recheninstitut*, who on Feb. 21 telegraphed the following ephemeris, which he had deduced from circular elements based on the two observations.

Greenw. M.T.	α	δ
Feb. 23.5	$4^h\ 4^m\ 28^s$	+25° 30′
27.5	4 9 28	+25 38
Mar. 3.5	4 14 48	+25 48

CORRIGENDA.

No. 292, p. 26, col. 2, line 37, *for* +40° 57′.8 *put* +48° 57′.8
302, p. 122, col. 2, *for* 5762 *X-Herculis* *put* 5758 *X Herculis*
305, p. 145, col. 1, " 5374 *S Librae* " 5374 *δ Librae*
No. 306, p. 153, line —2 *for* *Jahrbuch* 1887 *put* *Jahrbuch* 1817
308, p. 169, col. 1, *for* 3060 *U Can.min.* *put* 3060 *U Cancri*
309, p. 177, line 8, " +39° 23′.9 " +39° 29′.9

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ON POND'S DOUBLE-ALTITUDE OBSERVATIONS, 1825–35.

By S. C. CHANDLER.

I. Reduction of Observations.

In the year 1825 Pond devised a plan for the conjoint use of the Mural Circles of the Greenwich Observatory, for the purpose of absolute determination of polar distances. In the spring of that year he began a series of observations upon this principle which was prosecuted with great vigor and continuity for three years. After about eight months' interruption caused by the necessity of obtaining observations of a large number of smaller stars, for the completion of his Catalogue (the one containing 720 stars), the series was again resumed in 1829, although on a less extensive scale, and continued until his resignation of the post of Astronomer Royal at the end of 1835.

This beautiful series of observations may be regarded as one of the most remarkable in modern astronomy. Hitherto, however, astronomy has not reaped its benefits, from the fact of Pond's inadequate reduction of them.

Early in the summer of last year, after I had completed the calculations on the principal series of observations since 1840, available for the establishment of the law of the latitude-variation, it became apparent that the most essential element for further advancing our knowledge in regard thereto was the derivation of its various constants for the period anterior to 1840. In particular, in behalf of the attempt to investigate the nature of the variation of these constants from their mean values, it was necessary that the true value of the principal element, namely, the mean length of the 428-day period, should be fixed with the greatest possible precision.

Our main resource for establishing the principal epoch for this term, about 1840, lies in the vertical circle and prime-vertical observations at Pulkowa in 1840–43. Notwithstanding their extreme precision, these observations were concentrated within so short an interval that the disentanglement of the constants of two terms so nearly commensurate was difficult, and the epochs for both were subject to much uncertainty; as those who have read the papers in this Journal on the aberration-constant are aware.

Considering the necessities of the case, and the different series of data before 1840 at our disposal,* I concluded that the problem could best be solved by means of the series of reciprocal double-altitudes by Pond between 1825 and 1836, and that the labor of a reduction of them must be resolutely undertaken. The large amount of other work on hand would have discouraged this project, had I not happily received at this juncture, through the liberality of a friend of astronomy, a generous appropriation for the purpose of employing computers to assist in carrying on the work.

It is unnecessary here to enter into a description of the instruments, or to give more than a general account of the observations and their reduction. Pond's device for the use of the two Mural Circles, at once simple and effective, may be briefly explained as follows: A star, *A*, at a given culmination, was observed directly with one instrument, and by reflection with the other. Another star, *B*, was observed directly with both instruments. Half the difference of the circle-readings for *A* gives the apparent altitude affected by half the difference of corresponding circle-readings of the two instruments. Half the difference of the circle-readings for *B* gives directly this half difference of circle-readings; which, applied to the result for *A*, gives its absolute apparent altitude affected only by the mean flexure of the two instruments at that altitude. The polar stars observed at both culminations give the absolute latitude, which completes the data for finding the horizontal points and index errors of both instruments, and thence the absolute declination from each observation with each instrument, subject of course to flexure and division-error, and to the variation of latitude.

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* The discussions of Molyneux's, Bradley's, Brinkley's, Bessel's, Struve's and Madler's Dorpat observations, and other series, are in hand. (See *A.J.* XI, pp. 76, 83, 86; XII, pp. 19, 70.)

If the stars in the working-list be equally distributed, on any given night, between the two modes of observation, and properly alternated on succeeding nights both as respects the instrument and mode of observation used for any given star, it is manifest that, with any tolerable steadiness of instrumental zero-points for a period of several nights, the mean observed declinations for this period will be absolutely free from accidental errors in the determination of these zero-points on the individual nights. Now stability of zero-points is a feature of these mural circles which distinguishes them in a remarkable degree. Generally for days, frequently for weeks together, they remained constant within an amount corresponding to the probable errors of the individual values found from a great number of determinations on each night.

Nothing could better illustrate POND's peculiar genius as an astronomical observer than the sagacious common-sense displayed in this simple scheme, and the industry and pertinacity with which it was carried out for more than a decade. The rich mine of stellar measurements thus provided has remained practically unworked for sixty years, only now to yield a part of its priceless information, and to emphasize BESSEL's profound characterization of POND's work as the "*ne plus ultra* of astronomical observation."

POND's method of operating these admirable instruments was continued after his retirement and death, but, after a year or two, in a more desultory and less well-balanced fashion, and ultimately fell into practical desuetude. The Jones Circle was transferred to the Cape of Good Hope in 1839, in exchange for the Cape Circle, also by Jones, which was mounted at Greenwich, but scarcely used. The Troughton Circle was supplanted by the Transit-Circle in 1851. In view of the prolific and invaluable results which we are now able to extract from his eleven years' series, this abandonment is a circumstance which we can never cease to regret.

The series began in January 1825, soon after the installation of the Jones Circle, which, except in a few trivial details, was an exact counterpart of the Troughton Circle in use since 1812. But there were so many minor adjustments and alterations during the first three months, that I have acted on POND's recommendation that the definitive series be regarded as beginning 1825 April 1. All the observations were made with the twelve microscopes of the two circles, except those in the latter half of 1828 and the first months of 1829, when only two microscopes with each were used; except for *γ Draconis*, where the readings of the six were continued for the purpose of establishing the relation of these combinations. As also comparatively few reflection-observations were made during this interval, I have omitted this portion of the series on account of its want of homogeneity with the rest.

The position of the telescopes with reference to the circles was not shifted during the eleven years. Thus the same divisions always came under the microscopes for each star, except for the few which were carried over to the next pointer-reading by precession. This, though diminishing the value of the observations for the purpose of obtaining absolute zenith-distances, is an inestimable advantage for the present investigation, since the results for aberration and latitude-variation are free from the effect of division-errors. For this purely differential purpose the divisions may be regarded merely as arbitrary marks on the circle.

To eliminate completely the index-errors of the two instruments I have taken only the "reciprocal" observations; namely, those made simultaneously, directly and by reflection. These give the altitudes independently of the knowledge of the horizontal points of the circles, which may be and have been entirely ignored in these investigations.

All the observations so described being drawn from the Greenwich Annual Volumes, 1825–35,* and collected for each star, the material divided itself naturally into two classes; first, fundamental or other important bright stars, observed with great frequency in nearly all years, and in several months of the year; secondly, stars observed only a few times each. The second class were of no use for my present aim. From the first I selected 36 stars between the pole and +5° declination, as practically containing all the material which could be of any service for the required investigation. These stars are well distributed both in right-ascension and zenith-distance, conditions essential for eliminating possible systematic errors which could affect the constants to be deduced. These data comprised 7241 culminations, *i.e.*, double that number observations with both instruments. Of these 14482 observations, six were affected with large mistakes, and fifty-nine with discordances exceeding five times the probable error, for which an examination of the printed record † and of my reductions gave no explanation. Excluding these, we have the distribution shown in the following table, where *n* is the number of observed double-altitudes.

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*I desire to express my indebtedness to the Harvard College Observatory for the loan of these volumes; and, generally, for the use of its Library.

† A silly attempt was made in England in 1823 (*Phil. Mag.*, LXIII) to annoy and discredit POND, by allegations of inordinate discordances and errors of record in his observations. While the frivolous nature of these criticisms was easily exposed by BESSEL (*A.N.*, IV, 209), it is proper here especially to note the surprisingly small percentage of such mistakes which I have been able to detect in the prosecution of this work.

No.	Star	α	δ	n	No.	Star	α	δ	n
		h	°				h	°	
1	*α Andromedae*	0.0	28.2	195	19	*α Bootis*	14.1	20.1	288
2	*γ Pegasi*	0.1	14.2	99	20	*ε Bootis*	14.6	27.8	148
3	*α Cassiopeae*	0.5	55.6	91	21	*β Ursae minoris*	14.9	74.8	194
4	*α Ursae min. UC*	1.0	88.4	317	22	*α Coronae*	15.5	27.3	214
4	" " *LC*	1.0	88.4	257	23	*α Serpentis*	15.6	7.0	169
5	*α Arietis*	1.9	22.7	186	24	*α Herculis*	17.1	14.6	195
6	*α Tauri*	4.7	16.2	181	25	*α Ophiuchi*	17.5	12.7	219
7	*α Aurigae*	5.1	45.8	141	26	*α Lyrae*	18.5	38.6	292
8	*β Tauri*	5.3	28.5	135	27	*β Lyrae*	18.7	33.2	258
9	*α Orionis*	5.8	7.4	114	28	*ζ Aquilae*	19.0	13.6	205
10	*α² Geminorum*	7.4	32.3	209	29	*δ Draconis*	19.2	67.4	180
11	*α Canis minoris*	7.5	5.7	124	30	*γ Aquilae*	19.6	10.2	162
12	*β Geminorum*	7.6	28.4	216	31	*α Aquilae*	19.7	8.4	481
13	*α Leonis*	10.0	12.8	141	32	*β Aquilae*	19.8	6.0	164
14	*γ Leonis*	10.2	20.7	142	33	*α Cygni*	20.6	44.7	435
15	*α Ursae Majoris*	10.9	62.7	130	34	*α Cephei*	21.2	61.9	206
16	*δ Leonis*	11.1	21.5	116	35	*β Cephei*	21.4	69.8	203
17	*δ Ursae Majoris*	12.1	58.0	74	36	*α Pegasi*	22.9	14.3	161
18	*α Draconis*	14.0	65.2	134		Total observed altitudes, ...			7176

In the reduction of all of Pond's observations, which I hope to be able to complete, his values of the horizontal points will need a thorough re-investigation; but the present discussion is entirely independent of them, as I have above explained. The circle-differences will likewise then have to be overhauled, although a close scrutiny has convinced me that the changes from Pond's values will be relatively unimportant. Any errors in this latter element, while they do affect the individual altitudes here used, are practically entirely eliminated from the mean of successive observations in which the instruments are alternated for the direct and reflected observations, as I have also explained. This alternation obtains so completely in the actual arrangement of the observations, that the slight errors in Pond's determination of the circle-differences are absolutely without influence on the mean results.

With regard to errors of runs the printed record gives no information. It was Pond's habit to eliminate this by adjustment, as is also done in much modern practice, instead of applying it as a correction. In view of his punctiliousness in such matters of mechanical detail we might perhaps assume that it was thoroughly done, without further examination. Manifestly the effect of outstanding errors from this source will in no wise vitiate our present results, unless the possibility be admitted that the error of runs may have, as Airy has suggested, a periodical variation dependent on season, when the microscopes are left for a long time unadjusted. However improbable this may seem, it is important to inquire into the point closely. This I have accordingly done, as will appear.

The reduction of the observations has been conducted with the Pulkowa precession and nutation; with the aberration-constant 20″.500 (see *A.J.*, 298, p. 79); with Boss's proper motions (except for *Procyon*, where Auwers's values for this and the orbital motion have been used, with the correction —0″.017 to the former, to allow for the difference between Boss's and Auwers's systems of proper motion); and finally, with Bessel's refractions, after an investigation of the thermometric coefficient directly from Pond's observations, which will be presently given. With these elements the observed altitudes, — after reduction to the center of the instrument by the correction 0″.046 tan ζ, and the reduction to the meridian of the large number of circum-meridian observations of *Polaris*, — were reduced to 1830.0, and converted into declinations by the use of the provisional latitude 51° 28′ 38″.27, obtained from a part of the 574 observations of *Polaris*; namely, 299 observations which were made nearly simultaneously, and in nearly equal numbers at the two culminations. These resulting declinations then stand subject to a final correction for the true mean latitude, and for the latitude-variation, to be determined from this investigation. All the reductions were made with extreme care, to the nearest hundredth of a second. The reductions to mean place were interpolated to the actual hour of observation, from ephemerides computed at ten-day intervals, with daily differences and their variations. For greater accuracy the short terms of the nutation were not included in these ephemerides, but were afterwards applied to the individual observations.

In this way were derived 7176 determinations of the declinations of the 36 stars here to be discussed. The individual results and details of reduction will appear elsewhere. The condensation of them into a number of groups for each star will be given at the end of these papers.

It should be noted at the outset that the following results are necessarily independent of division-errors and of flexure.

These only come in question in considering the absolute character of the declinations. However, it is worth while to note, in passing, that, from the mode of attachment of the telescope to the circle in this class of instruments, the tube-flexure disappears. The only flexure which we should expect, *a priori*, is the change in the circle-flexure consequent on slightly loading the ends of a single diameter; * and this, on mechanical principles, is probably very small. Bessel himself remarked this circumstance in connection with the Königsberg Cary Circle, where the same mechanical principle of construction enters. It was also confirmed practically by Laugier's experience with the Gambey Mural Circle.

Several observers took part in the observations, but their work is so distributed that the only effect of any systematic personal differences in bisections is to increase the apparent accidental error. Ultimately I intend to examine the results intimately on this point, but for the present purpose it may be disregarded.

A topic which obviously needs critical study is the effect of temperature on the refraction. We have little information as to the correctness of the meteorological instruments or of their exposure. The readings were frequent, and the calculations of the refraction present no difficulty on that score. The difference between the inner and outer thermometers averaged 2° F., or less, at night, but frequently reached 4° or 5° near noon. In order to be as nearly as possible independent of error in thermometer-exposure, I have made a determination of the expansion-coefficient from the observations themselves. The volumes from 1825 to 1835 were searched for all lower culminations near the horizon, and from this material were selected eight stars observed at from 6° to 17° altitude, with variations of temperature ranging from 22° to 45° (average, 32°); the total refractions ranging between 200″ and 500″, and their differences due to temperature-variations ranging from 15″ to 45″. These data are practically all that Pond's observations afford for the purpose, and seem sufficient to establish the coefficient with all needful precision, and to exclude suspicion of appreciable error of this sort from the results for aberration and latitude-variation hereafter deduced.

The following table gives the results of this investigation, the details of which it is needless to present here. The column "*e*" contains the values of the atmospheric expansion-coefficient for one degree Fahrenheit, derived by least-squares for the several stars. The columns of observed ranges of temperature and refraction will give an idea of the sufficiency of the data. The weights in the last column are the coefficients of *e* in the equations from which the corrections to the several declinations have been eliminated.

Star	ζ	Range of Temp.	Range of Refraction	Obs.	*e*	Wt.
	°	° °	″ ″			
α Cygni,	83.7	32–51	502–479	11	0.003685	2406
α Aurigae,	82.6	19–64	445–405	10	3647	11403
α Persei,	79.3	23–62	314–289	5	3532	2117
η Ursae Maj.,	78.3	21–48	287–271	41	3535	3642
γ Draconis,	77.0	19–51	259–243	50	3795	4468
β Draconis,	76.0	19–46	242–229	16	3390	1363
γ Ursae Maj.,	73.8	26–57	206–193	43	3779	1451
α Cassiopeae,	72.9	16–57	198–182	36	3786	1190
Mean value, by weights, ...					0.003650 ± 27	

Comparing with the standard values,

Bessel,	0.003644
Gyldén,	.003689
Regnault,	0.003665

it is apparent that the atmospheric temperature was indicated by the thermometer with tolerable correctness, and that the Königsberg coefficient represents the observed value better than the Pulkowa one; thus justifying its use in the reductions.

We may further infer that there is no fear of systematic error from uncertainty in the thermometer-coefficient, amounting to ±0″.05 even at 46° zenith-distance, corresponding to the southernmost of the stars used in the latitude-variation and aberration discussions, or of as much as ±0″.01 for most of the stars. Further, since the stars are distributed on both sides of the zenith, even this slight possible error must be eliminated from the mean of all. Even if there exist, as has been suspected, a difference in the ratio of expansion at different seasons, it will be similarly eliminated. The coefficient of the annual term in the variation of latitude, as well as the aberration, hereafter found, are consequently beyond suspicion from this sort of error. Later on in these papers a further and more direct demonstration of this will be given, by a determination of these quantities separately from stars north and south of the zenith.

Naturally the constant of general refraction from Pond's observations has no interest for our immediate purpose. Nevertheless, as a test of the correctness of the use of Bessel's constant, in getting absolute declinations from them, I add the values of the latitude found by combining these lower-culmination observations with those at upper culmination, for the four stars for which I have the data reduced.

Star	ζ	φ	Obs. U	Obs. L
	°	″		
α Cygni,	83.7	38.69	435	11
α Aurigae,	82.6	38.20	141	10
γ Draconis,	77.0	38.48	564	50
α Cassiopeae,	72.9	38.53	91	36
Mean by weights		38.49 ± 0″.04		
Polaris,		38.42 (hereafter found)		

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* Or, more exactly, what load is not borne by the spindle is distributed by the braces among four spokes, in opposite pairs, near the periphery.

No appreciable correction to Bessel's general constant is therefore required by Pond's observations.

Let us next examine the question of accidental errors, not only to ascertain the quality of the observations, but also to fix the relative weights for subsequently combining the different stars. This examination has been conducted in two ways. First, groups were taken, in the observations 1825–28, each containing generally from 20 to 30 altitudes covering intervals of two or three months near the points of maximum and minimum latitude, as indicated by the subsequent investigation. The deviations from the mean declination of each group, summed without regard to sign, give the probable error of a single altitude as shown in the column r in the table, by the formula,

$$r = 0.8453 \frac{[v]}{n-m}$$

These values are nearly, but not quite free from the latitude-variation. But this method is open to the objection that it does not represent the real exactitude of the observations, since it includes one element — namely, the accidental error of the adopted values of the circle-differences — which is practically eliminated from the mean results, as I have above explained. A fairer way is to consider the probable error of an altitude found by combining two observations of it made with the instruments alternated, as respects direct and reflected vision, on successive nights, it being assumed that no change took place in either instrument in 24 hours' intervals. Thus, secondly, means were taken for all the independent pairs of such observations (also from 1825–28), that could be found for each star. These were then corrected for variation of latitude, according to the formula hereafter given, and the probable errors were found from the squared deviations from the mean for each star, in the usual manner. These are given in the second part of the table, in the column r'.

Star	ζ	n	m	[v]	r	n′	[v′v′]	r′
	°			″	″		″	″
11	+45.8	77	5	40.32	±0.47	30	2.60	±0.20
32	45.5	54	3	34.79	.57	15	2.73	.30
23	44.5	76	3	40.06	.46	35	8.76	.34
9	44.1	60	3	35.93	.53	21	3.73	.29
31	43.1	195	4	99.74	.44	100	22.35	.22
30	41.3	51	3	34.82	.61	18	4.45	.34
13	38.7	86	3	40.96	.42	26	3.50	.25
25	38.8	68	3	33.11	.43	52	7.05	.25
28	37.9	67	3	28.09	.39	42	4.14	.21
24	36.9	69	3	32.75	.42	45	5.82	.24
2	37.3	50	3	28.56	.52	11	1.15	.23
36	37.2	83	2	46.07	.48	23	2.55	.23
6	35.3	73	3	44.25	.53	30	5.46	.29
19	31.4	99	3	49.37	.43	59	11.99	.31
14	30.8	73	3	36.52	.44	22	2.16	.22
16	30.0	71	3	35.74	.44	20	1.16	.17
5	28.8	65	3	44.86	.61	33	6.06	.29
22	24.2	83	3	34.33	.36	45	7.55	.28
20	+23.7	76	3	36.11	±0.42	31	5.18	±0.28
12	+23.1	69	3	34.67	±0.44	36	6.92	±0.30
1	23.3	55	2	25.53	.41	29	6.55	.33
8	23.0	58	3	27.57	.42	19	4.59	.34
10	19.2	71	3	35.78	.45	38	4.45	.23
27	18.3	92	3	42.52	.41	60	7.60	.24
26	12.9	86	2	47.07	.47	55	7.39	.25
33	6.8	246	5	118.07	.41	107	15.50	.26
7	+ 5.7	66	3	33.43	.45	19	2.24	.24
3	— 4.1	52	3	33.35	.57	19	4.30	.33
17	6.5	46	2	21.62	.41	18	2.88	.28
34	10.4	94	2	59.17	.54	34	5.77	.28
18	13.7	69	3	34.72	.45	25	4.06	.28
15	11.2	78	3	44.22	.50	27	4.52	.28
29	15.9	46	3	19.78	.39	30	6.57	.32
35	18.3	92	2	41.46	.39	32	1.80	.16
21	23.3	69	2	38.10	.48	32	5.75	.29
4 U	36.9	144	7	70.12	.43	60	13.37	.32
4 L	—39.9	130	5	53.47	±0.36	50	6.96	±0.25

Combining the above in groups, we have,

Stars	ζ	r	r
	°	″	″
5	+44.6	±0.480	±0.305
4	39.2	.445	.251
4	36.7	.485	.255
4	30.2	.476	.272
5	23.5	.409	.300
3	16.8	.440	.242
4	+ 0.5	.440	.267
6	—15.5	.464	.273
1	—38.4	±0.400	±0.292

which may be expressed approximately by

$$r^2 = 0''.436^2 + 0''.170^2 \tan^2\zeta$$
$$r'^2 = 0.270^2 + 0.070^2 \tan^2\zeta$$

From the zenithal values we get

$$\sqrt{0''.436^2 - 2[0''.270^2]} = \pm 0''.210$$

which may be regarded as very near the probable error due to the uncertainty in the value of one-half of the "circle-difference," or the difference of the index-errors of the two instruments, in the observed value of a single altitude The remainder, or

$$\sqrt{0''.436^2 - 0''.210^2} = \pm 0''.382$$

represents the probable error of the observation itself.

For convenience, I add the following table, by which the above values, given in the table against numbers 1 and 9, may be compared with others which may be fairly regarded as standards of the best work at different epochs, and with different classes of instruments. The juxtaposition of the last two values — headed "Complete Observation" for want of a better phrase — seems to be a fair one, from the analogy subsisting between the four circum-meridian altitudes, East and West, and in reversed positions of the Vertical Circle, and the four observations with the Mural Circles — namely, two with each circle, direct and reflected — practically employed by the two methods for the complete determination of a zenith-distance to which the probable error in each case refers.

	Instrument	Apert.	Circ.	r^2	
	SINGLE OBSERVATION				
1	Mural Circle, Greenwich, Troughton & Jones	4 in.	6 ft.	$0''.436^2 + 0''.170^2 \tan^2 \zeta$	
"	" " Greenwich, Troughton & Jones	4	6	$.382^2$	(*a*)
2	" " Paris, Gambey	–	6.5	$.405^2 + .128^2 \tan^2 \zeta$	
3	Transit Circle, Greenwich, Troughton	8	6	$.618^2 + .165^2 \tan^2 \zeta$	
4	Meridian Circle, Königsberg, Reichenbach	4	3	$.713^2$	
5	" " Königsberg, Repsold	4	3	$.464^2$	
6	" " Leyden, Pistor & Martins	6	3	$.459^2 + .207^2 \tan^2 \zeta$	(*b*)
7	" " Leipsic, " "	6	3	$.432^2 + .218^2 \tan^2 (\zeta - 10°)$	
8	Vertical Circle, Pulkowa, Ertel	5.9	3.6	$.395^2$	
	COMPLETE OBSERVATION				
9	Mural Circle, Greenwich, Troughton & Jones	4	6	$.270^2 + .070^2 \tan^2 \zeta$	
10	Vertical Circle, Pulkowa, Ertel	5.9	3.6	$0.220^2 + 0.200^2 \tan^2 \zeta$	

NOTES.

(*a*). Eliminating the effect of POND's values of "Circle-differences."

(*b*). KAISER found 0″.382 and 0″.384, at 4° and 16° zenith-distance, respectively, from observations of VALENTINER and KAMPF alone.

Authorities: 1 and 9, present paper; 2, LAUGIER, *A.N.*, XLVI, 197: 3, MARTH, *A.N.*, LIII, 192; 4, BESSEL, Königs., Vol. VII; 5, LUTHER, *A.N.*, XLV, 309; 6, BECKER, Leyd., Vol. II, 145; 7, ENGELMANN, *ibid*: 8 and 10, deduced from NYRÉN's data, Pulkowa, Vol. XIV, (30), (34).

The values found from observations by a single observer are: 2, LAUGIER; 4 and 5, BESSEL; 7, ENGELMANN; 8 and 10, NYRÉN and GYLDÉN separately. The others (1, 3, 6, 9), were found from the mixed observations of several observers, and hence involve the effect of personal differences.

The result, then, of this discussion of accidental error is to show that POND attained, with these instruments and this method, a degree of refinement in this respect which not only excels that of any similar work contemporaneous with it, but which has been scarcely surpassed anywhere, or at any time. In the subsequent presentation of the discussion of the astronomical constants — including those of the variation of latitude, the aberration and the nutation, as well as stellar parallaxes and declinations — deduced from this work, the probable freedom of these mural circles from systematic error will appear in an equally favorable light.

OBSERVATIONS OF VARIABLE STARS,

BY J. A. PARKHURST.

These notes form a continuation of the paper published in No. 310. The observations were made with a 6.2-inch reflector.

678. *U Persei.*

Thirty-five observations from 1893 Aug. 7 to 1894 Feb. 5, yield a well-defined minimum $< 12^{M}$ 1893 Nov. 15. The light-curve is smooth, the increase a little quicker than the decrease.

1623. *T Camelopardalis.*

This star was nearly stationary from 1893 Oct. 3 to Nov. 17 at $8^{M}.5$. It then rose quickly to a maximum of $7^{M}.0$ 1894 Jan. 3, followed by a secondary maximum equally bright Jan. 29, and a third of $8^{M}.0$ Feb. 19. I have 25 observations from 1893 Sept. 13 to 1894 Mar. 6.

2815. *U Geminorum.*

My observation of 1893 Dec. 3 showed that this star was $< 12^{M}$; one by Mr. YENDELL Dec. 4 showed it to be $< 11^{M}$, Dec. 6.9 it was $9^{M}.2$. Ten observations from Dec. 6 to 21, indicate a maximum of $9^{M}.2$ about Dec. 8.0. On Dec. 21 it had fallen to $< 12^{M}$.

3825. *R Ursae Majoris.*

A maximum of $7^{M}.5$ 1893 Oct. 14 is shown by 29 observations, extending from 1893 July 10 to 1894 Feb. 5.

4511. *T Ursae Majoris.*

This star passed a maximum of $7^{M}.6$ 1893 Dec. 29. I have 23 observations from 1893 Oct. 9 to 1894 March 6.

4557. *S Ursae Majoris.*

Between 1893 Oct. 7 and 1894 March 6 I have 25 observations of this star, yielding a maximum of $7^{M}.8$ 1893 Dec. 14.

5338. *U Bootis.*

I observed this star 16 times from 1893 Oct. 9 to 1894 Jan. 16. A minimum $<12^{\mathrm{M}}$ is clearly indicated for 1893 Dec. 12. This would give a correction of +49 days to the elements given by Chandler in his Second Catalogue.

8116. *W Cephei.*

Twenty-eight observations from 1894 Jan. 8 to March 2 yield three well-defined maxima Jan. 16, 24, and Feb. 22, besides three less certainly Feb. 1, 15, and March 1. Combining the last with Yendell's first maximum, 1893 Nov. 22.0 (*A.J.*, no. 310) gives a period of $7^{\mathrm{d}}.2$. The maxima were $7^{\mathrm{M}}.5$; the least observed light was $8^{\mathrm{M}}.0$.

DM. 58°2560 (*Cassiopea*).

$\alpha = 23^{\mathrm{h}}\ 5^{\mathrm{m}}\ 27^{\mathrm{s}}$, $\delta = +58°\ 53'.8$ (1855).

This new variable discovered by Anderson (*Astr. Nachr.*, 3205), and confirmed by Hartwig (*A.N.*, 3211), has been under observation since 1894 Jan. 18. When first seen it was $>10^{\mathrm{M}}$. It has gradually declined till March 6, when it was $<12^{\mathrm{M}}$.

Marengo, Ill., 1894 *March* 7.

OBSERVATION OF A MAXIMUM OF 1805 *V ORIONIS*.

[From a Letter of Dr. L. de Ball to the Editor.]

I permit myself to mention some observations of the variable 1805 *V Orionis*, which, judging from the communication published in no. 310 of the *Astronomical Journal*, may be of interest.

This star I compared, at Liege, with a series of neighboring stars, from 1890 Dec. 8 to 1891 April 9, using the ten-inch refractor. The days of observation were 1890 Dec. 8, 11, 29, 30, 31; 1891 Jan. 2, 25, 30; Feb. 7, 13, 21, 22, 24, 26; Mar. 22, 23, 31; Apr. 9. The places of the variable, and of those comparison-stars which serve for the determination of the maximum, are for the mean equinox of 1875.0:

Star	Albany Cata.	Magn. Alb. C.	α	δ	Adopted Magn.
			h m s	° ′	
m	1566	8.9	4 59 0.8	+3 59.8	8.8
a	1567	9.6	4 59 18.7	+3 52.1	(9.6.)
V Orionis	–	–	4 59 28.3	+3 55.8	–
b	1572	8.6	4 59 51.9	+3 51.2	8.7
L	1590	8.6	5 2 52.4	+2 56.7	8.5

On Dec. 8 and 11, *V Orionis* was connected by estimates of steps with stars not cited here, and estimated as fainter than *a* by half a magnitude. From Dec. 29 till Jan. 2, *V Orionis* and *a* appeared to be of equal magnitude. From Jan. 25 to Feb. 26, *m*, *b* and *L* were employed as comparison-stars; at the next observation, on March 22, *V* had already become so much fainter that it was requisite to use other stars than the three last mentioned, for the comparisons. On March 31 the variable was still brighter than *a* by two steps; but, on April 9, it was one step fainter than *a*. Making use of the adopted magnitudes of the comparison-stars and of $0^{\mathrm{M}}.07$ as the value for one step, we obtain from the comparison of *V Orionis* with *m*, *b* and *L* the following magnitudes of the variable near the time of the maximum.

	V Orionis	Comp.-Stars
	M	
1891 Jan. 25	8.75	*b*, *m*
30	8.7	*b*, *m*
Feb. 7	8.6	*b*, *m*
13	8.5	*b*
21	8.6	*b*, *m*, *L*
22	8.6	*b*, *m*, *L*
24	8.65	*b*, *m*, *L*
26	8.6	*b*, *m*, *L*

From the total of these observations, it results that a maximum of *V Orionis* occurred near the middle of February, 1891.

Von Kuffner Observatory, Vienna, 1894 *Feb.* 16.

VARIABLES OF SHORT PERIOD,

By A. W. ROBERTS.

Argentine Zone-Catalogue, X, 2067.

R.A. = $10^{\mathrm{h}}\ 28^{\mathrm{m}}\ 29^{\mathrm{s}}$, Decl. = $-57°\ 51'\ 15''$ (1875).

The observations of this star extend from the first of June 1893 to the present time, and yield the following elements:

Period,	3.637 days.
Rise to maximum,	0.92 days.
Maximum epoch,	1894 Feb. 9.2
Limits of variation,	$7^{\mathrm{M}}.8$ to $8^{\mathrm{M}}.6$

In the *Zone-Catalogue* the magnitude is given as $8\frac{1}{2}$.

Argentine Zone-Catalogue, XV, 3946.

R.A. = $15^{\mathrm{h}}\ 56^{\mathrm{m}}\ 13^{\mathrm{s}}$, Decl. = $-62°\ 34'\ 0''$ (1875).

The observations of this star extend from July 1893 to the present time, and yield the following elements:

Period,	2.546 days.
Ascending period,	0.76 days.
Epoch of maximum,	1894 Feb. 7.7.
Limits of variation,	$7^{\mathrm{M}}.7$ to $8^{\mathrm{M}}.7$.

In the *Zone-Catalogue* the magnitude is given as $8^{\mathrm{M}}.0$.

Lovedale, Alice, South Africa, 1894 *Feb.* 9.

NEW ASTRONOMICAL WORK.

Tobias Mayer's *Sternverzeichniss nach den Beobachtungen auf der Göttinger Sternwarte in den Jahren* 1756 *bis* 1760, *neu bearbeitet von* Arthur Auwers. Leipsic, 1894.

Of the three great practical astronomers who, near the middle of the last century, undertook the task of determining the positions of planets and stars with a degree of precision vastly greater than that which had hitherto been attempted, Bradley ranks easily first. Nevertheless, the comparative inattention with which astronomers for more than a century regarded the labors of LaCaille, at the Cape of Good Hope, upon the principal southern stars, and of Tobias Mayer, at Gottingen, upon the Zodiacal stars, appears inexplicable. Less than twenty years ago Dr. Powalky rescued LaCaille's fundamental-star observations from the prolonged neglect which they had suffered. The present work by Dr. Auwers demonstrates for the first time the real value of the meridian observations made by Tobias Mayer.

These observations, with appliances inferior to those enjoyed by Bradley, were begun contemporaneously with the outbreak of the Seven Years' war. The quartering of a hostile garrison in Göttingen (the lower part of his observatory was used by the enemy for a powder magazine) brought many evils in its train for Mayer, over and above the disturbance of mind inseparable from existence in turbulent times.

In his exhaustive reduction of these observations, Dr. Auwers presents a catalogue containing the positions of 1027 stars, and the results of 47 planetary observations, of which several are incomplete. Of these stars, 345 do not occur in the catalogue of Bradley, and there are 45 others for which Bradley's observations are defective.

In Mayer's observations, both right-ascension and declination were obtained by the use of the quadrant. Dr. Auwers finds it necessary to treat this series in a differential way, and employs the new Bradley catalogue as standard, using in right-ascension 574 stars and in declination 559 stars, observed by Bradley four and three times at least respectively. By means of repeated and most thorough computations and comparisons he has obtained instrumental constants and corrections for Mayer's quadrant, the application of which results in star-positions which are systematically homogeneous with those of Auwers's Bradley. Incidentally he notes that Mayer's surmises in respect to the deformation of the plane of his quadrant appear to be well grounded.

The resulting catalogue is constructed for the epoch 1755. For the stars not well determined by Bradley, special evaluations of the proper motion for each star are set forth in sufficient detail. For this purpose, comparison is made chiefly with the catalogues of Zach, Piazzi, Taylor, Königsberg zodiacal stars, and of observations at Gotha made especially for this purpose. In many instances the discussion is still more complete. The catalogue also contains numerous references to other catalogues, and exhibits comparisons with Bradley, and with Baily's edition of Mayer's catalogue. The agreement with Bradley seems surprisingly good; and Dr. Auwers has otherwise shown that, in the differential sense, the right-ascensions determined by Mayer are quite comparable in precision with those by Bradley, while the declinations are not materially inferior. As might have been expected, the discordances from Baily's edition of Mayer's catalogue are large, both in the systematic and in the differential sense. The systematic deviations exceed 7″ in places, and those of an accidental nature are often much greater.

Unfortunately, the record of Mayer's zenith-distance observations for the period from Feb. 8 to May 21, 1856 (except for 28 observations in February) is lost. This loss affects the reduction in declination for 454 stars; and of these, the declinations of 222 stars would have been entirely wanting, had the construction of the catalogue been made dependent on the existing record alone. Accordingly, Dr. Auwers has determined the corrections necessary to reduce the declinations given in Baily's Mayer to systematic conformity with his own results, and has then transferred these corrected declinations to the present catalogue, wherever such a course became necessary to supply an unavoidable deficiency.

By this work, Dr. Auwers has laid the world under new obligations, not only for the very great value of virtually new material for investigation which he has produced, but also for calling renewed attention to the profound merits of a great astronomer, who, although he suffered much in his later years, and was cut off at an age when most men are becoming fairly launched in professional life, yet accomplished a vast and varied amount of most important work with a high degree of foresight and ripe intelligence.

NEW ASTEROIDS.

Prof. Krueger communicates the photographic discovery of one by Courty at Bordeaux, Feb. 11, and two by Wolf at Heidelberg, March 1.

AV	11^M	Feb. 11	$10^h\,47^m.5$	Bordeaux M.T.	$\alpha = 9^h\,58^m\,24^s$,	$\delta = +22°\,24'$;	Daily motion, -58^s in α, and $4'$ northward.
AX	8^M	Mar. 1	9 40.0	Heidelberg M.T.	11 4 36,	+ 6 59;	" " -76^s in α, and 0 in decl.
AY	12^M	Mar. 1	9 40.0	" "	11 14 0,	+ 4 8;	" " -48^s in α, and $8'$ northward.

The planet 12^M found by Dr. Wilson on his photograph of Jan. 30 is provisionally designated as *AW*.

CORRIGENDUM.

Vol. XII, p. 195, col. 1, Max. of 7085 *RT Cygni*, *for* Nov. 3, *put* Dec. 8.

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Observation of a Maximum of 1805 U Orionis, by Dr. L. de Ball.
Variables of Short Period, by Mr. A. W. Roberts.
New Astronomical Work.
New Asteroids.
Corrigendum.

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MEASURES OF THE POSITION OF THE SATELLITE OF *NEPTUNE*, 1893-4,

MADE WITH THE 36-INCH EQUATORIAL OF THE LICK OBSERVATORY,

By E. E. BARNARD.

The following measures of the satellite of *Neptune* are a continuation of those printed in *A.J.*, 290.

Like the previous measures, they are in Standard Pacific Time, which is eight hours slow of Greenwich.

In each case the position-angle has been measured first, the wires then set perpendicular to the line between the satellite and *Neptune* by the aid of the position-circle (I have given the *reading of the circle* for this setting in each case), and the distance then measured.

1893 *November* 12.

h m s	Circle °	P.A. °	
14 13 28	271.0	70.2	Parallel = 290°.8
14 14 50	271.3	70.5	
14 16 21	271.5	70.7	
14 17 58	271.5	70.7	

Distance from Center of *Neptune*.

h m s	r	″
14 20 55	28.306	16.90
14 22 20	28.331	16.63
14 23 48	28.335	16.62

Threads interchanged.

h m s	r	″	
14 24 49	31.714	16.84	Coincidence of threads = $30^{r}.013$
14 25 53	31.726	16.96	
14 26 50	31.695	16.66	

Setting of position-circle for distances = 361°.5

1893 *November* 13.

h m s	Circle °	P.A. °	
14 11 35	231.6	30.9	Parallel = 290°.7
14 14 50	231.6	30.9	
14 16 14	230.0	29.3	
14 17 25	230.7	30.0	

Distance from Center of *Neptune*.

h m s	r	″
14 20 15	31.204	12.38
14 21 27	31.270	13.03
14 22 35	31.261	12.96
14 23 50	31.234	12.68

Threads interchanged.

h m s	Circle r	P.A. ″	
14 25 23	28.632	13.09	Coincidence of threads = $29^{r}.954$
14 26 15	28.642	12.99	
14 26 59	28.655	12.87	
14 28 23	28.657	12.85	

Setting of position-circle for distances = 321°.0.

1893 *December* 3.

h m s	Circle °	P.A. °	
9 48 35	68.0	239.8	Parallel = 98°.2
9 50 40	68.2	240.0	
9 51 50	67.8	239.6	
9 53 30	68.5	240.3	

Distance from Center of *Neptune*

h m s	r	″
9 55 55	18.930	16.53
9 56 55	18.919	16.64
9 58 10	18.935	16.48

Threads interchanged.

h m s	r	″	
9 59 42	22.275	16.60	Coincidence of threads = $20^{r}.599$
10 0 52	22.275	16.60	
10 2 15	22.311	16.95	

Setting of position-circle for distances = 158°.0

1893 *December* 10.

h m s	Circle °	P.A. °	
10 26 0	10.5	181.0	Parallel = 279°.5
10 27 20	8.8	179.3	
10 29 0	11.3	181.8	
10 30 20	9.8	180.3	

Angles poor.

Distance from Center of *Neptune*.

h m s	r	″
10 35 25	21.695	10.86
10 36 17	21.671	10.63
10 37 5	21.684	10.76

Threads interchanged.

h m s	r	″	
10 37 50	19.480	11.07	Coincidence of threads = $20^{r}.598$
10 38 40	19.533	10.55	
10 39 20	19.564	10.24	

Setting of position-circle for distances = 23°.0.

A faint star 15^{M} was observed near *Neptune* on this date.

h m s	Circle °	P.A. °	
10 8 47	293.2	283.7	
10 16 0	293.7	284.2	
11 23 50	297.5	288.0	(uncertain)

Distance from Center of *Neptune*.

h m s	r	″
10 20 50	22.821	22.01
10 22 20	22.958	23.37
11 28 40	22.140	15.27
11 33 0	22.395	17.80

Very difficult.

1894 *January* 7.

h m s	Circle °	P.A. °	
10 29 5	23.2	250.0	Parallel = 43°.2
10 31 5	22.8	249.6	
10 32 30	22.4	249.2	
10 33 35	22.4	249.2	

Distance from Center of *Neptune*.

h m s	r	″
10 38 30	23.212	17.32
10 39 40	23.164	16.84
10 40 55	23.210	17.30

Threads interchanged.

h m s	r	″	
10 42 4	19.782	16.65	Coincidence of threads
10 43 10	19.713	17.33	= $21^{r}.463$
10 44 25	19.855	15.92	

Setting of position-circle for distances = 292°.5.

Satellite very faint and difficult. Frost on object glass.

1894 *January* 10.

h m s	Circle °	P.A. °	
8 54 24	23.2	70.1	Parallel = 43°.1
8 55 47	22.4	69.3	
8 57 2	23.2	70.1	
8 57 47	24.0	70.9	

Distance from Center of *Neptune*.

h m s	r	″
8 59 57	19.825	16.48
9 1 2	19.817	16.56
9 1 57	19.793	16.80

Threads interchanged.

h m s	r	″	
9 2 57	23.119	16.14	Coincidence of threads
9 4 6	23.165	16.60	= 21 .489
9 5 17	23.170	16.65	

Setting of position-circle for distances = 113°.0.

1894 *January* 21.

h m s	Circle °	P.A. °	
10 17 56	70.8	102.0	Parallel = 58°.8
10 20 41	70.8	102.0	
10 21 41	70.2	101.4	
10 22 36	70.1	101.3	

Distance from Center of *Neptune*.

h m s	r	″
10 24 36	22.730	12.28
10 26 11	22.755	12.53
10 26 56	22.724	12.22

Threads interchanged.

h m s	Circle r	P.A. ″	
10 27 46	20.226	12.52	Coincidence of threads
10 28 51	20.164	13.13	= $21^{r}.490$
10 29 41	20.304	11.75	

Setting of position-circle for distances = 160°.5.

1894 *January* 22.

h m s	Circle °	P.A. °	
8 26 10	210.1	61.2	Parallel = 58°.9
8 27 40	210.1	61.2	
8 30 25	210.2	61.3	
8 31 35	209.8	60.9	

Distance from Center of *Neptune*.

h m s	r	″
8 33 15	19.819	16.61
8 34 35	19.806	16.75
8 35 30	19.769	17.11

Threads interchanged.

h m s	r	″	
8 36 25	23.187	16.74	Coincidence of threads
8 37 25	23.149	16.36	= $21^{r}.497$
8 36 35	23.268	17.54	

Setting of position-circle for distances = 120°.0.

1894 *January* 28.

h m s	Circle °	P.A. °	
7 15 30	208.4	59.1	Parallel = 239°.3
7 17 20	207.7	58.4	
7 18 58	208.5	59.2	
7 20 15	207.8	58.5	

Distance from Center of *Neptune*.

h m s	r	″	
7 23 26	19.856	16.32	Coincidence of threads
7 24 23	19.797	16.90	= $21^{r}.504$
7 26 0	19.845	16.43	

Threads interchanged.

h m s	r	″
7 27 15	23.157	16.37
7 28 25	23.185	16.65
7 29 33	23.187	16.67

Setting of position-circle for distances = 298°.0.

A very faint star, $16\frac{1}{2}^{\mathrm{M}}$, near *Neptune*.

h m s	Circle °	P.A. °
7 57 0	120.2	330.9
7 59 0	120.2	330.9

Distance from Center of *Neptune*.

h m s	r	″
8 3 35	18.101	33.70
8 5 10	18.131	33.40

1894 *February* 26.

h m s	Circle °	P.A. °	
7 42 40	83.7	71.1	Parallel = 102°.6
7 43 50	84.1	71.5	
7 44 25	84.2	71.6	
7 45 40	84.0	71.4	

Distance from Center of *Neptune*.

h m s	Circle r	P.A. ″
7 47 25	33.148	15.84
7 49 5	33.153	15.89
7 49 50	33.168	16.04

Threads interchanged.

h m s	Circle r	P.A. ″
7 51 0	29.911	15.91
7 51 45	29.951	15.82
8 0 50	29.932	16.00

Coincidence of threads $= 31^r.518$

Setting of position-circle for distances = 174°.0.

MAXIMA AND MINIMA OF SHORT-PERIOD VARIABLES, OBSERVED IN 1893,

BY PAUL S. YENDELL.

6368. *X Sagittarii.*

From 1893 May 6 to Sept. 20, my observations of *X Sagittarii* number twenty-nine. From these are deduced the following maxima and minima.

Maxima				Minima	
1893	w	1893	w	1893	w
May 17.24	1	Aug. 7.89	2	May 7.62	1
23.20	1	15.40	1	June 10.44	1
July 4.40	1	29.48	2	Sept. 2.84	2
10.89	2	Sept. 6.32	1	10.54	2
17.77	3	12.58	3	17.07	1
Aug. 2.41	2	19.93	1		

6472. *W Sagittarii.*

I have thirty-five observations of *W Sagittarii*, from 1893 May 6 to Sept. 20; these indicate maxima and minima as follows:

Maxima				Minima	
1893	w	1893	w	1893	w
May 18.10	1	Aug. 8.40	3	May 6.52	1
24.20	1	15.38	1	July 14.25	2
July 1.09	2	30.10	2	20.80	3
8.40	3	Sept. 6.70	3	Aug. 5.40	2
16.60	3	14.87	2	Sept. 4.50	2
23.79	1			11.60	3

6573. *Y Sagittarii.*

I have thirty-nine observations of this star, from 1893 May 6 to Sept. 28, from which are deduced the following maxima and minima:

Maxima				Minima	
1893	w	1893	w	1893	w
May 4.62	1	Aug. 4.70	2	July 4.40	1
9.96	1	10.81	3	10.50	1
15.98	1	15.75	1	16.46	1
June 30.84	1	Sept. 1.73	5	Aug. 2.85	1
July 6.86	2	8.27	2	8.90	3
12.97	3	13.83	2	13.40	2
				Sept. 6.30	3
				12.20	3
				28.35	1

6636. *U Sagittarii.*

I have observed this star thirty-one times during the season, from 1893 May 6 to Oct. 12; the maxima and minima deduced from these observations are as follows:

Maxima				Minima			
1893	w	1893	w	1893	w	1893	w
May 3.90	1	Sept. 9.48	4	June 10.44	1	Aug. 9.86	1
17.42	1	15.48	1	July 6.08	2	29.85	2
July 10.41	1	21.06	1	14.77	1	Sept. 6.32	1
Aug. 13.83	2	Oct. 5.92	1	21.06	3	13.14	2
Sept. 2.70	3	12.97	1	Aug. 2.82	2	Oct. 9.91	1

6984. *U Aquilae.*

From 1893 May 18 to Oct. 14 I have thirty-two observations of *U Aquilae*, which indicate the following times of maxima and minima:

Maxima				Minima	
1893	w	1893	w	1893	w
July 12.15	3	Aug. 30.14	4	July 16.91	1
19.59	2	Sept. 6.57	3	Aug. 13.84	1
Aug. 8.98	3	20.16	1	Sept. 4.74	1
16.27	1	Oct. 11.62	4	10.40	1

7483. *T Vulpeculae.*

This star has been followed from 1893 April 23 to Nov. 11, the observations numbering sixty-five in all. Maxima and minima are indicated as follows:

Maxima				Minima	
1893	w	1893	w	1893	w
Apr. 22.71	1	Aug. 11.17	2	May 8.67	1
May 6.29	1	15.93	1	June 4.13	1
19.43	2	20.61	1	30.89	2
23.65	1	29.33	1	July 19.40	1
June 1.69	1	Sept. 3.01	3	23.39	1
10.42	1	7.23	1	Aug. 5.42	1
July 2.85	1	11.98	3	Sept. 6.32	1
7.28	1	16.31	1	28.35	1
16.33	1	20.31	1	Oct. 11.49	2
20.49	2	Oct. 4.76	1	16.97	1
24.82	1	13.10	2	20.88	1
29.56	1	17.45	2	Nov. 11.25	1
Aug. 2.82	2	21.31	1		

The above times of maxima and minima were mostly obtained by the use of mean light-curves formed from my own observations. The weights assigned indicate the number of observations from which each date is deduced; and no distinction has been made of the few cases where the phase was sharply indicated by the single curves.

The time used is, as usual, the local mean time.

The season's observations of 7149 *S Sagittae*, 6758 *β Lyrae*, 7437 *X Cygni*, and 8073 *δ Cephei*, are reserved for future publication.

Dorchester, Mass., 1894 *March* 3.

NOTES ON VARIABLE STARS. — No. 3.

By HENRY M. PARKHURST.

Results of Observations.

No.	Star	Phase	Observed Date Julian	Observed Date Calendar 1893, 4	E	Corr.	Remarks
7795	*RV Cygni*	Min.	2467	Jan. 3	–	–	
..	..	Max.	2781	Nov. 13	–	–	
..	..	Max.	2829	Dec. 31	–	–	
..	..	Min.	2855	Jan. 26	–	–	Irregular fluctuations
7907	*U Aquarii*	Max.	2808	Dec. 10	26	— 5	Another maximum two months earlier
8068	*S Lacertae*	Max	2853	Jan. 24	–	–	Period probably 149 days
8153	*R Lacertae*	Max.	2748	Oct. 11	13	— 6	Possibly a little earlier
8230	*S Aquarii*	Max.	2704	Aug. 28	44	+ 2	
8373	*S Pegasi*	Min.	2852:	Jan. 23	34	–	Rough estimate; probably not earlier
8512	*R Aquarii*	Min.	2835	Jan. 6	78	–	Corresponds with M — m = 179
8597	*V Ceti*	Max.	2810	Dec. 12	20	0	
8600	*R Cassiopeae*	Min.	2837	Jan. 8	34	+ 3	
114	*S Ceti*	Max.	2838	Jan. 9	24	—21	
513	*R Piscium*	Max.	2911	Mar. 23	29	0:	Prediction; lost in the twilight
715	*S Arietis*	Max.	2752	Oct. 15	27	— 4	
..	..	Max.	2752	Oct. 15	27	— 1	Derived from the following elements, in which the two inconsistent obs. long prior to the epoch are rejected: $0^d4872 + 292.4\,E + 20^d \sin(18° E + 195°)$
806	o *Ceti*	Min.	2765	Oct. 28	30	0:	Prediction; probably not much later
..	"	Max.	2904	Mar. 16	30	+27	Possibly still later
845	*R Ceti*	Min.	2821:	Dec. 23	59	+10	Invisible for 72 days
..	"	Max.	2886	Feb. 26	59	+ 5	
906	*R Trianguli*	Min.	2846	Jan. 17	5	+14	
1113	*U Arietis*	Max.	2791	Nov. 23	–	–	Period probably a little over a year

Individual Observations.

7795 *RV Cygni*

Julian	Calendar	Mag.
d	1892-4	
2453	Dec. 20	8.6
2471	Jan. 7	9.1
2480	16	8.5
2490	26	8.5
2498	Feb. 3	8.5
2739	Oct. 2	8.6
2747	10	8.39_2
2755	18	8.64_2
2762	25	8.32_2
2768	31	8.63_2
2774	Nov. 6	8.70_2
2779	11	8.59_2
2783	15	8.05_2
2784	16	8.68_2
2786	18	8.44_2
2788	20	8.68_2
2798	30	8.75_2
2810	Dec. 12	8.86_2
2821	23	8.52_2
2834	Jan. 5	7.66_2
2837	8	7.55_2
2842	13	8.7
2843	14	8.65_2
2848	19	9.25_2
2860	31	8.94_2
2871	Feb. 11	8.51_2
2880	20	8.6

7907 *U Aquarii.*

Julian	Calendar	Mag.
d	1893, 4	
2744	Oct. 7	10.4
2746	9	10.54_2
2768	31	10.95_2
2778	Nov. 10	11.09_2
2798	30	11.0
2805	Dec. 7	10.4
2810	12	10.6
2822	24	10.9

8068 *S Lacertae*

Julian	Calendar	Mag.
2744	Oct. 7	11]
2747	10	11]
2767	30	11]
2778	Nov. 10	11.1
2805	Dec. 7	10.2
2808	10	10.39_2
2816	18	10.04
2821	23	9.37_2
2829	31	9.06_2
2837	Jan. 8	8.63_2
2846	17	8.50_2
2849	20	7.99_2
2851	22	8.30_3
2860	31	8.12_2
2866	Feb. 6	8.57_2
2870	10	8.44_2
2880	20	9.2

8153 *R Lacertae*

Julian	Calendar	Mag.
d	1893, 4	
2744	Oct 7	9.7
2747	10	9.55_2
2754	17	9.88_2
2767	30	9.78_2
2777	Nov. 9	10.11_2

8230 *S Aquarii*

Julian	Calendar	Mag.
2694	Aug. 18	8.2
2697	21	8.00_2
2701	25	7.69_2
2705	29	7.41_2
2710	Sept. 3	7.71_2
2713	6	8.98_2

8373 *S Pegasi*

Julian	Calendar	Mag.
2745	Oct. 8	10.1
2779	Nov. 11	11.65_2
2810	Dec. 12	12.83_2
2822	24	12.9
2830	Jan. 1	13.0]
2837	8	13.42_2
2852	23 to	
2866	Feb. 6	12.8]

4 obs.

8512 *R Aquarii*

Julian	Calendar	Mag.
2745	Oct. 8	10.0
d	1893, 4	
2779	Nov. 11	10.21_2
2804	Dec. 6	10.77_2
2818	20	11.00_2
2823	25	11.95_2
2830	Jan. 1	11.55_2
2837	8	11.95_2
2854	25	11.24_2

8597 *V Ceti*

Julian	Calendar	Mag.
2751	Oct. 14	12.3]
2805	Dec. 7	10.7
2808	10	10.56_2
2818	20	10.77_2

8600 *R Cassiopeae*

Julian	Calendar	Mag.
2481	Jan. 17	11.0
2818	Dec. 20	11.23_2
2830	Jan. 1	11.99_2
2837	8	12.40_2
2852	23	11.41_2:
2860	31	11.2
2866	Feb. 6	11.19_2:

114 *S Ceti*

Julian	Calendar	Mag.
2742	Oct. 5	11.8
2744	7	11.8
2768	31	10.8
d	1893, 4	
2810	Dec. 12	8.6
2821	23	8.20_2
2846	Jan. 17	6.81_2
2851	22	7.77_2
2854	25	7.93_2
2865	Feb. 5	8.42_2

513 *R Piscium*

Julian	Calendar	Mag.
2887	Feb. 27	9.13_2
2891	Mar. 3	8.93_2

715 *S Arietis*

Julian	Calendar	Mag.
2745	Oct. 8	11.4
2746	9	11.97_2
2747	10	11.83_2
2748	11	11.58_2
2751	14	11.37_2
2754	17	11.62_2
2755	18	11.58_2
2762	25	11.4]
2766	29	11.80_2

806 o *Ceti*

Julian	Calendar	Mag.
2771	Nov. 3	9.0
2804	Dec. 6	8.9
2836	Jan. 7	8.8
2848	19	8.32_2

806 *o Ceti*—Cont.

Julian	Calendar	Mag.
d	1894	
2857	Jan. 28	7.96_2
2866	Feb. 6	7.35_2
2868	8	6.96_2
2870	10	6.91_2
2871	11	7.38_2
2875	15	6.03_2
2876	16	5.14_2
2880	20	4.69_2
2883	23	4.43_2
2884	24	4.45_2
2887	27	4.41_2
2888	28	4.32_2
2891	Mar. 3	4.25_2

806 *o Ceti*—Cont.

Julian	Calendar	Mag.
d	1893, 4	
2895	Mar. 7	3.32_2
2898	10	3.53_2
2900	12	4.23_2
2901	13	3.95_3
2902	14	3.61_2
2904	16	2.84_2
2905	17	3.54_2
2907	19	3.79_4
2911	23	3.44_4

845 *R Ceti*

Julian	Calendar	Mag.
2771	Nov. 3	11.2 :
2777	9	12.35_2

845 *R Ceti* — Cont.

Julian	Calendar	Mag.
d	1893, 4	
2783	Nov. 15	12.23_2
2804	Dec. 6	13 0]
2810	12	13.0]
2822	24	13.0]
2829	31	13.0]
2831	Jan. 2	13.0 :
2836	7	13.0]
2837	8	13.0]
2852	23	12.30_2
2883	Feb. 23	9.13_2
2888	28	9.13_2
2891	Mar.. 3	9.47_2

906 *R Trianguli*

Julian	Calendar	Mag.
d	1893, 4	
2819	Dec. 12	11.35_2
2827	29	11.95_2
2837	Jan. 8	12.02_2
2860	31	11.76_2
2866	6	11.85_2
2870	10	11.80_2
2883	23	11.22_2

1113 *U Arietis*

Julian	Calendar	Mag.
2769	Nov. 1	9.7
2770	2	9.03_2
2777	9	8.60_2
2783	15	8.92_2

1113 *U Arietis* — Cont.

Julian	Calendar	Mag.
d	1893, 4	
2786	Nov. 18	8.88_2
2788	20	8.28_2
2798	30	8.88_2
2805	Dec. 7	9.23_2
2837	Jan. 8	10.1
2854	25	11.75_2
2862	Feb. 2	10.67_2
2868	8	11.11_2
2883	23	11.55_2
2895	Mar. 7	11.8
2911	23	11.8]

COMPARISON-STARS.

7795 *RV Cygni*

I	+37°4104	7.53	14
K	+37°4405	8.30	20
N	+37°4418	9.06	12
R	+37°4401	9.42	10
S	+37°4398	10.01	6
U	+37°4399	9.62	2
X	+37°4400	10.07	2

7795 *RV Cygni* — Cont.

2*X*	+37°4408	9.85	1
Y	+37°4402	10.95	1

8068 *S Lacertae*

I	+39°4856	7.88	7
L	+39°4886	8.39	2M
O	+39°4883	8.73	2M

8068 *S Lacertae* — Cont.

R	+39°4857	8.80	7
1*R*	+39°4858	8.80	6
T	+39°4835	9.34	5M
U	+39°4862	9.69	5
W	+39°4846	9.65	6
Y	+39°4853	10.26	6
Z	+39°4854	11.31	1

8068 *S Lacertae* — Cont.

a	2*n*4*f*	*U*	10.47	2
c	1*s*2*p*	*U*	10.95	1
d	2*s*3*f*	*U*	11.15	1
e	2*s*	*Z*	11.33	1

1113 *U Arietis*

X	+14°525	9.82	1

1113 *U Arietis* — Cont.

Z	+14°527		9.69	8
1*Z*	+14°529		10.04	8
2*Z*	+14°532		10.41	5
a	7*n*17*p*	*Z*	9.76	1
b	4*s*9*f*	2*Z*	9.80	1
c	10*n*6*p*	*Z*	10.81	3
f	double 9*n*1*f*	*Z*	11.60	3

NOTE ON NYRÉN'S VERTICAL-CIRCLE OBSERVATIONS, 1882-91,

By S. C. CHANDLER.

The extreme interest attaching to this important series of observations, and the conclusions drawn therefrom by NYRÉN (*A.N.* 3166) with regard to the latitude-variation, together with KOSTINSKY's interesting remarks (*A.N.* 3209), lead me to offer one or two considerations which I trust these gentlemen will not regard as intrusive.

Mr. KOSTINSKY has made a comparison of NYRÉN's observed dates of maximum and minimum phases with the complete equation (15), and suggests that there may be an error in the enumeration of the periods included by the series, and that the anomalies in the residuals may be reconciled by assuming that nine, instead of eight, is the correct number. This is true as respects the number of epicyclical revolutions of the poles, but not so, it seems to me, as respects the effective number of oscillations which NYRÉN's process of discussion was adapted to bring out. NYRÉN shows, on the first page of his article, that the nature and distribution of his material is such as not directly or readily to permit the determination of an annual term, and he limits himself to a mode of treatment which will demonstrate only the existence of any period different from a year. His results afford most convincing evidence of the fourteen months' term. Further, his epochs of the principal phases agree very well in general with the first term of equation (15), thus:

MAXIMA.			MINIMA.		
NYRÉN	Comp	O—C	NYRÉN	Comp.	O—C
1882.46	1882.42	+0.04	1882.97	1883.01	—0.04
83.60	83.60	.00	84.30	84.19	+ .11
84.83	84.78	+ .05	85.29	85.37	— .08
85.97	85.96	+ .01	86.56	86.55	+ .01
87.15	87.14	+ .01	87.78	87.74	+ .14
88.31	88.33	— .02	89.17	88.92	+ .25
89.61	89.51	+ .10	90.18	90.09	+ .09
90.78	90.69	+ .09	1891.28	1891.28	0.00
1891.94	1891.87	+0.07			

On the other hand, it is important to observe that the effect of the annual term is not fully eliminated. This could be rigorously done only by using observations of each star made at the same time of the year. They are actually distributed over an appreciable interval, in each of them. The resultant curve will therefore differ from the sinoid representing the fourteen months' term alone, in a degree dependent upon the proportion of stars whose observations cover a considerable portion of the year. It is manifest, from the description (on p. 356, *A.N.*, 3166) of the difference in the material for 1889-91 from that of previous years, that we ought to expect that the curve would approximate quite closely in the later years to the full equation (15); and it will be found on trial that such is the case. If I am correct in this, we ought, in the shape in which the results at present stand, to compare the curve-phases with the first term of eq. (15) alone from 1882–88, as in the above table; and with the full expression from 1889–91, as is done by Kostinsky.

I hope that either Mr. Nyrén or Mr. Kostinsky will think favorably enough of this suggestion — which I have no doubt has occurred to them independently — to discuss the material further with a view to separate the elements of the two terms; for it would be much to be deplored if astronomy should lose the full fruits of this admirable series of observations.

Cambridge, 1894 *Feb.* 22.

OBSERVATIONS OF 7437 *X CYGNI* FOR THE YEAR 1893, WITH A NOTE ON (8100) *CEPHEI*,

By PAUL S. YENDELL.

My observations of *X Cygni* for 1893 extend from May 6 to 1894 Jan. 1, and are eighty-six in number. They indicate the following maxima and minima:

Maxima				Minima			
E	1893	w	Lt.	E.	1893	w	Lt.
150	July 2.5	3	12.4	150			
151	July 19.5	4	13.4	151	July 14.4	4	6.1
152	Aug. 4.3	4	11.4:	152	July 30.4	3	6.1
153	Aug. 22.9	3	12.4	153	Aug. 14.8	4	5.1
154	Sept. 7.6	4	11.7	154	Aug. 31.0	4	6.0
155				155	Sept. 15.7	3	
156	Oct. 10.6	4	11.4	156			
157	Oct. 27.2	2	9.7:	157	Oct. 17.6	4	3.0
158	Nov. 11.2	4	11.4	158	Nov. 3.4	4	1.0
159	Nov. 26.6	4	10.4	159	Nov. 18.6	3	3.0
160				160	Dec. 5.0	2	1.0
161	Dec. 30.4	4	10.4	161			

The brightest maximum and minimum occur at E. 151, and the faintest at E. 158.

Upon assembling all my observed maxima and minima, about one hundred and fifty in number, and extending over a space of six years, it was apparent that the cycle that I had assigned, of twenty-one periods of the star, was too short, the recent minima on this curve falling late. The term best satisfying the observations was found to be twenty-two periods, $= 360^{d}.558$, and was so nearly coincident with a year as at once to arouse a suspicion of the subjective character of the phenomenon. The greatest and least observed brightness were found to occur, on the average, at the same seasons each year, and an inquiry into the position-angle of the line joining the star and its principal comparison-star leaves no doubt that the apparent periodicity of this variation is simply the optical effect of the progressively varying angle between the axial line of this group and the line joining the axes of the eyes.

Aside from this apparent fluctuation, the star certainly shows occasional faint minima, when it goes below the entire usual group of comparison-stars by several steps, as see Dunér's minimum at E. 93, and my own at E. 138, 158, and 160, when the star was well below the usual minimum light, a comparison-star off the axial line of the usual group being employed.

In Vol. X of this Journal, p. 141, I published, under date of 1892 March 3, the announcement of the probable variability of the star now on Chandler's Unconfirmed List as (8100) *Cephei.*

This announcement was very cautiously made, after eighteen months' continuous observation, and seemed at the time to be warranted; but although I had at various times suspected the influence of changing hour-angle in a star of so high northern declination, the balance of evidence seemed to me strongly to favor the star's variability.

The variation, however, has not, so far as I know, been confirmed; and I have been led since its announcement, to doubt its reality, especially as Mr. Sawyer's observations, made at my request on both sides of the meridian, fail to show any change; and I have on several occasions called to Dr. Chandler's notice the advisability of removing it from his Unconfirmed List. My own observations have continued to indicate the same apparent change, but in a period of so exactly a year, that the conclusion is forced upon me that the apparent variation is, as in the case of *X Cygni*, a matter of hour-angle. This conclusion receives a strong confirmation from a comparison of the changes of the two stars with their changing hour-angles, as tabulated below, their position-angles relative to the principal comparison-stars used in each case being very nearly the converse of each other.

The subjoined table is self-explanatory; the hour-angles and brightness are in the case of (8100) *Cephei* the means of the assembled monthly groups, and in that of *X Cygni* of one-hour groups; the weights, *w*, indicate the number of observations from which each mean was formed; the residuals, *d*, are the departures from the graphic means of the different series. Both *L* and *d* are expressed in steps of the working light-scales for the two stars, the average value of a step being about $0^{M}.09$.

(8100) *Cephei.* 7437 *X Cygni*

Hour-Angle	Light (Steps)	*d* (Steps)	Maxima Light	Maxima *d*	Maxima *w*	Minima Light	Minima *d*	Minima *w*
h m			st.	st.	″	st.	st.	″
East 8 9	8.2	—3.6						
7 37			10.2	—1.4	1			
7 6						6.4	+1.15	2
6 51	7.1	—4.7						
6 45			12.4	+0.8	3			
6 19						6.4	+1.15	2
6 3			12.9	+1.3	9			
5 35						6.5	+1.25	3
5 29			11.4	—0.2	2			
4 59	7.6	—4.2						
3 50			12.7	+1.1	12			
3 45						6 45	+1.20	12
2 44						6.8	+1.55	8
2 19	8.3	—3.5						
2 11						6.1	+0.85	5
1 49			12.4	+0.8	8			
1 20	8.5	—3.3						
1 6			12.3	+0.7	10			
0 57						7.2	+1.95	1
0 22	9.3	—2.5						
West								
0 45						4.9	—0.35	4
0 55			11.0	—0.6	8			
1 1	13.8	+2.0						
1 45						4.3	—0.95	9
West 2 22			10.4	—1.2	11			
2 26	15.4	+3.6						
3 3						3.7	—1.55	11
3 34			10.4	—1.2	9			
3 43						3.8	—1.45	11
5 16						4.7	—0.55	3
5 17	16.8	+5.0						
5 46			11.1	—0.5	5			
7 2	14.4	+2.6						
8 55	12.8	+1.0						
11 33	11.8	±0.0						

The features common to both cases will be perceived upon examining the above table; the persistence, in the column *d*. of the same sign on each side of the meridian; the suddenness with which the sign changes in both cases as the hour-angle passes from East to West, and *vice versa*; the correspondence of the signs to the relative position-angles of the axial lines of the star-groups; and the regular progression of the change indicated, especially in the case of (8100). All of these features seem to point definitely and strongly to a common cause, and to my mind, dispose completely of the entire question of the variability of (8100), and of the supposed long-period variation of *X Cygni*.

Dorchester, Mass., 1894 *March* 17.

COMET *a* 1894.

A faint comet was discovered March 26, by Denning, at Bristol, England; and observed as follows:—

1894 March 26.396 Greenw. M.T., $\alpha = 9^h\ 55^m$, $\delta = +32°\ 15'$; Daily motion about 1° south following.

Observations have been received from Prof. Boss at Albany, Mr. Taylor Reed at Princeton, Dr. Wilson at Northfield, and Prof. Porter of Cincinnati. The details must be deferred to the next number, for want of room.

Prof. Boss sends the positions

March 27	8h 58m 38s Albany M.T.	$\alpha =$ 9h 59m 4s.09,	$\delta =$ +31° 34′ 56″.2
29	12 3 36	10 6 45.24,	+30 24 42.1
April 1	11 18 55	10 16 46.99,	+28 47 40.7

The observations of the April 1 position were obtained with difficulty, owing to the state of the sky.

The comet is estimated to be of the twelfth magnitude-equivalent; the nebulosity is estimated to be one and a half minutes in diameter with a fan-shaped extension about 5′ in length in approximate position angle 150°.

Mr. Reed's observation is

March 27 11h 20m 25s E.Std. Time. $\alpha = 9^h\ 59^m\ 26^s.55$, $\delta = +31°\ 31'\ 31''.0$.

Dr. Wilson telegraphs the positions

March 28.6552 Greenwich M.T.	$\alpha =$ 10h 3m 1s.6	$\delta =$ +30° 58′ 2″
29.6516 " "	10 6 35.0	+30 26 30

Prof. Porter sends the observations

March 29	8h 25m 57s Cincinnati M.T.	$\alpha =$ 10h 6m 21s.20	$\delta =$ +30° 28′ 39″.1
30	8 28 36	10 9 50.00	+29 55 46.0

ELEMENTS AND EPHEMERIS OF COMET *a* 1894 (*DENNING*),

By LEWIS BOSS,

From Albany observations, March 27–29, April 1.

$T = 1894$ Feb. 17.273 Greenw. M.T.

$$\left.\begin{aligned} \omega &= 64^\circ\,37'.9 \\ \Omega &= 72\;\;12.3 \\ i &= \;\;6\;\;32.4 \end{aligned}\right\}\text{Apparent equinox}$$

$\log q = 0.09520$

The computations indicate possible eccentricity.

Ephemeris for Greenwich Midnight.

1894	App. α	App. δ	log Δ	Brightness
	h m s	° ′		
April 4.5	10 25 44	+27 16	9.7476	0.73
8.5	10 37 28	+25 9	9.7747	0.62
12.5	10 48 14	+23 6	9.8024	0.52
16.5	10 58 11	+21 9	9.8303	0.44
20.5	11 7 26	+19 16	9.8583	0.37
24.5	11 16 4	+17 30	9.8863	0.31
28.5	11 24 10	+15 48	9.9142	0.26

NEW ASTEROIDS.

Prof. Krueger communicates the discovery of another small planet by Courty at Bordeaux, and two by Charlois at Nice, and their positions as follows:

AZ	10^M	1894 Mar. 5	$10^h\,15^m.6$ Bordeaux M.T.	$\alpha = 9^h\,34^m\,24^s$,	$\delta = +23^\circ\;8'$.	
		7	8 29.3 " "	9 33 0,	+23 19.	
BA	12^M	1894 Mar. 7	9 53.0 Nice M.T.	10 41 12,	+10 56;	Daily motion, -48^s in α, and 3′ northward.
BB	11^M	1894 Mar. 8	11 39.0 "	9 32 8,	+ 3 50;	Daily motion, -40^s in α, and 2′ northward.

NEW ASTRONOMICAL WORK.

Traité Analytique des Orbites Absolues des huit Planètes Principales par Hugo Gyldén. Tom. I. *Théorie Générale des Orbites Absolues.* Stockholm, 1893. 4^{to}, pp. 573.

The expressions, heretofore given for the coordinates of the planets, are open to the serious objection of being serviceable only for a limited range of time: and it is well known that for some time Prof. Gyldén has been at work devising modifications in the way of approaching the subject which would lead to expressions free from the mentioned imperfections. This volume contains the general principles of the method he proposes for attaining this end. However, it appears that some additional explanation will be required before any application can be made to a particular case. This Prof. Gyldén announces will be given in the portions of the work still to follow.

To carry out this plan to its last degree of perfection, in the case of the solar system, would require an amount of labor, in comparison to which, that of Delaunay in the lunar theory would be a mere bagatelle. However, taking the matter in a somewhat rough way, it may be possible to arrive at results interesting for their indications of what may be called general tendencies in the motion of the solar system.

To give a notion of the general character of Prof. Gyldén's method, we may begin by saying that the methods, proposed by Prof. Newcomb and M. Lindstedt, lead to expressions consisting of an infinite series of purely periodic terms, and identical with those which would be obtained through the application of the procedure of Delaunay in the lunar theory. These methods give directly, and without the intervention of auxiliary quantities, the coordinates of the bodies. But these expressions have been shown by M. Poincaré to be destitute of rigorous mathematical convergence: that is, they possess only the quality of semi-convergence, and, like the expressions employed by Laplace and Hansen, can be made to represent the values of the coordinates for only a limited interval of time. Prof. Gyldén, therefore, proposes to abandon the explicit expression of these quantities as functions of the time, and, separating the inequalities which depend on the mutual configuration of the planets, he would determine the remainder, called by him elementary terms, by themselves. And afterwards he would make the complete values of the coordinates depend on the latter. However, if we understand the matter rightly, Prof. Gyldén would express all the auxiliary quantities, employed for the exhibition of the planetary positions, by means of circular functions of the time; for, in the few instances in which elliptic functions are introduced, they appear only as machinery of demonstration.

What degree of success will attend the application of this method can be clearly seen only when the numerical labor, involved by treating some special case, shall have been accomplished.

CORRIGENDUM.

No. 313, p. 4, col. 1, line —9, *for* Fahrenheit *put* Centigrade.

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Corrigendum.

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ON POND'S DOUBLE-ALTITUDE OBSERVATIONS, 1825–35,

BY S. C. CHANDLER.

II. VARIATION OF LATITUDE.

The methods employed in the following discussions have been to some extent governed by the distribution of the material. The general chronological classification of the observations is as follows:

Year	No.	Year	No.
1825	1430	1831	351
1826	1835	1832	424
1827	1248	1833	451
1828	462	1834	460
1829	123	1835	229
1830	163	Total	7176

The classification by stars has been given in *A.J.*, 313, p. 3.

The rigorous method of treatment would have been to form and solve 7176 equations of condition with five unknowns (six for *Polaris*), according to eq. (29).[*] This would have been so manifestly a waste of labor that I proceeded to determine the various constants by successive approximation.

The first step was to collect the observed declinations, for each of the 36 stars, into means embracing generally ten or twelve-day intervals. The two culminations of *Polaris* were treated separately. In all the subsequent computations these means were used strictly according to their weights by numbers of observations; and no rejections were made for any reason whatever.

The next step was to make a first approximation to the true mean declinations δ_0, free from the latitude-variation. If the observations for the several stars had been pretty uniformly distributed chronologically, this would be represented sufficiently well by the mean of the observations. But this condition is so far from being satisfied by most of the stars that the assumption is not allowable. It is evident, however, that the differences of simultaneously observed declinations of any two stars must be free from latitude-variation. Therefore, if any of the stars are so continuously observed that the above condition is approximately fulfilled, we may, by the use of the simultaneous differences of the other stars from these, arrive at approximate values of δ_0 for all of them. An examination shows that this condition is satisfied by *Polaris* and *α Cygni*. Accordingly, all the remaining 34 stars were referred to these two in this manner, and with these first approximations to δ_0 preliminary values of n, eq. (26), were formed, and the results for the various stars combined, giving a chronological series of values of $\Delta\varphi$. These, when charted, presented a distinct curve, closely approximating to that shown in the plate accompanying this number, which is the result of the second approximation presently to be described. Indeed, not only as a whole, but when separated into parts, in groups of stars, or even by the individual stars most numerously observed, the same characteristic features of the curve were clearly indicated; so that, even at this early stage of the investigation, there remained no reasonable doubt as to the reality of the phenomenon. There is no need to burden this paper with the numerical details of the discussion up to this point. It suffices to say that a provisional numerical formula for the latitude-variation was thus derived, closely accordant with those hereafter given; and that a comparison of the epoch of its fourteen months' term, 1830 Mar. 1 = 2389513, with the other available data seems to point to the value 428.6 days as the mean length of this period, corresponding to the mean daily rate of angular rotation, $\theta = 0^\circ.840$. But it also now appears nearly certain that this period is not strictly uniform. With this remark I must pass the subject, as the general inquiry into the variations of this and the other coefficients of the latitude-variation, must be adjourned until the completion of calculations upon other series; any definite inferences would be partial and premature at the present time.

A second approximation was now made to the values of

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[*] To save repetition all formulas here employed will be referred to by their numbers in *A.J.*, 287, pp. 177, 8; and all individual symbols will be strictly used according to the definitions there given.

δ_0 by correcting all the observed declinations by the provisional latitude-formula, and taking the means. These are still referred to the provisional value of the mean latitude, 51° 28′ 38″.27, used in the reductions, (see p. 3), although the use of all the observations of *Polaris* at both culminations gave 51° 28′ 38″.42; but, as this is still subject to a final correction, it was not thought desirable to introduce it at this stage.

The provisional formula for the variation also enables us to determine normal values of $\Delta\varphi$ for a given series of dates at convenient equidistant intervals, by reducing the original observed declinations for the several stars, within each interval, to the middle date, by a process similar to that by which normal places for comets and planets are formed. This greatly simplifies the subsequent computations, in an entirely unobjectionable manner. Thus, selecting normal dates 60 days apart, reducing the observed declinations to them, forming new values of n, and combining the stars by weights according to the observations, we have the observed values of $\Delta\varphi$ in the fifth column of the table below.

t		Number		$\varphi-\varphi_0$	
Calendar	Julian	Obs.	Stars	Obs.	Comp.
1825 May 3	= 2 387 750	236	21	−0.27	−0.24
July 2	7 810	446	16	− .12	− .14
Aug. 31	7 870	367	20	+ .12	+ .07
Oct. 30	7 930	270	16	+ .21	+ .19
Dec. 29	7 990	274	22	+ .17	+ .13
1826 Feb. 27	8 050	280	21	+ .03	− .02
Apr. 28	8 110	315	21	− .08	− .13
June 27	8 170	394	15	− .16	− .10
Aug. 26	8 230	334	26	+ .02	+ .01
Oct. 25	8 290	243	20	+ .02	+ .08
Dec. 24	8 350	165	19	− .03	+ .05
1827 Feb. 22	8 410	141	13	− .11	− .03
Apr. 23	8 470	244	19	− .08	− .04
June 22	8 530	319	18	− .08	+ .01
Aug. 21	8 590	202	23	+ .04	+ .06
Oct. 20	8 650	198	14	+ .01	+ .05
Dec. 19	8 710	133	13	− .14	− .05
1828 Feb. 17	8 770	122	14	− .10	− .12
Apr. 17	8 830	9	3	+ .06	− .07
June 16	8 890	106	10	− .02	+ .07
Aug. 15	8 950	145	19	+ .15	+ .17
Oct. 14	9 010	29	7	+ .19	+ .13
Dec. 13	9 070	–	–	–	− .05
1829 Feb. 11	9 130	–	–	–	− .21
Apr. 12	9 190	4	2	+ .11	− .19
June 11	9 250	24	5	− .04	+ .02
Aug. 10	9 310	56	16	+ .25	+ .22
Oct. 9	9 370	29	10	− .10	+ .25
Dec. 8	9 430	11	5	+ .01	+ .05
1830 Feb. 6	9 490	16	6	− .43	− .21
Apr. 7	9 550	36	7	− .40	− .29
June 6	9 610	33	9	+ .18	− .11
Aug. 5	= 2 389 670	19	7	+0.06	+0.16
1830 Oct. 4	= 2 389 730	19	9	+0.55	+0.30
Dec. 3	9 790	41	13	+ .22	+ .20
1831 Feb. 1	9 850	20	11	− .19	− .09
Apr. 2	9 910	47	11	− .10	− .28
June 1	2 389 970	75	10	+ .08	− .21
July 31	2 390 030	97	14	− .07	+ .02
Sept. 29	0 090	61	12	+ .27	+ .23
Nov. 28	0 150	50	5	+ .26	+ .23
1832 Jan. 27	0 210	19	6	− .27	+ .03
Mar. 27	0 270	69	9	− .12	− .17
May 26	0 330	72	8	− .13	− .20
July 25	0 390	88	12	− .18	− .07
Sept. 23	0 450	106	9	+ .03	+ .11
Nov. 22	0 510	68	12	+ .31	+ .20
1833 Jan. 21	0 570	36	8	− .16	+ .07
Mar. 22	0 630	29	5	+ .26	− .06
May 21	0 690	76	10	+ .09	− .10
July 20	0 750	116	12	− .14	− .05
Sept. 18	0 810	131	11	+ .23	+ .04
Nov. 17	0 870	63	10	+ .05	+ .05
1834 Jan. 16	0 930	48	8	− .12	− .01
Mar. 17	0 990	71	7	− .18	− .05
May 16	1 050	–		–	− .02
July 15	1 110	90	9	+ .12	+ .06
Sept. 13	1 170	166	12	+ .32	+ .09
Nov. 12	1 230	71	7	+ .12	+ .01
1835 Jan. 11	1 290	33	5	− .27	− .11
Mar. 12	1 350	75	8	+ .11	− .17
May 11	1 410	11	5	− .15	− .03
July 10	1 470	33	5	+ .13	+ .13
Sept. 8	1 530	45	12	+ .44	+ .20
Nov. 7	1 590	33	5	− .01	+ .09
1836 Jan. 6	= 2 391 650	17	6	0.00	−0.13

The values in the above table are graphically represented in the chart accompanying this number. Some slight numerical corrections were made in the computations after the chart was engraved, but the latter is accurate enough for its general illustrative purpose. The small figures placed against the several observed points are the numbers of observations in the third column of the table. The superior smoothness of the observed curve before 1829 is obviously accounted for by the far greater number of observations during that period.

Considering the diagram attentively — and entirely apart from the dotted curve representing the values computed from the formula hereinafter deduced — a striking feature will be noticed. The observed variations in 1826–7 and 1833–4 are decidedly smaller than for the years intervening, or for those before and after. This characteristic is especially pronounced in the earlier portions of the curve, where the observations are very numerous. The total range of the variations between the middle of 1826 and the end of 1827 is not over a fifth of a second, while that of

1825 is double, and that of 1830 is treble this amount. The increasing range after 1833 is also visible, but is less distinct on account of the smaller number of observations. The epicyclical character, required by the announced law of the latitude-variation, appears thus to be finely illustrated by POND's observations, which consequently afford an independent verification of it. This is the more satisfactory and important, as it assures a high degree of confidence in the values of the constants of the numerical index of the merit which must in future attach to this long-neglected series of observations.

To find the constants from the above observed values of $\Delta\varphi$, we put u and π equal to zero in eq. (28) so that (29) becomes

$$x_0 + y\sin\gamma + z\cos\gamma + \iota\sin\odot + \zeta\cos\odot = n$$

where the constant x_0 is of course an arbitrary unknown. Assuming in (25) the values $T_0' = 2389513$ and $\theta = 0^\circ.84$, we form equations of condition, using, for convenience

where $\varepsilon_1, \varepsilon_2, \varepsilon_3, \varepsilon_4$ are the probable errors of y, z, ι, ζ.

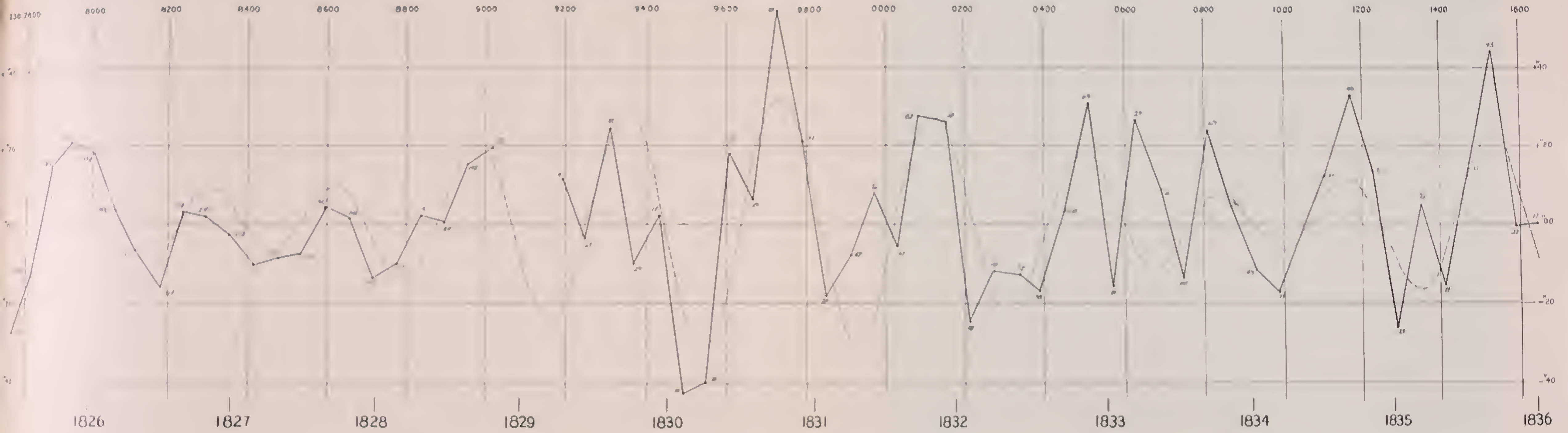
The agreement of the two portions of the series is all that we could reasonably expect. Adding the normal equations, and solving for the whole series, we have,

$x_0 = +0''.007$, $y = -0''.0142 \pm 0''.150$, $z = -0''.1250 \pm 0''.0118$, $\iota = -0''.0115$, $\pm 0''.0156$, $\zeta = -0''.1668 + 0''.0146$

whence,

$$\varphi - \varphi_0 = \underset{\pm 0.015}{-0''.126}\cos(t - \underset{\pm 8.0}{2389520.7)\,0.84} \quad \underset{\pm 0.015}{-0''.173}\cos(\odot - \underset{\pm 4.9}{14.9}) \qquad (49)$$

Variation of Latitude: **Pond's Observations. 1825-36.** (7176 obs. of 36 Stars.)



1825 is double, and that of 1830 is treble this amount. The increasing range after 1833 is also visible, but is less distinct on account of the smaller number of observations. The epicyclical character, required by the announced law of the latitude-variation, appears thus to be finely illustrated by POND's observations, which consequently afford an independent verification of it. This is the more satisfactory and important, as it assures a high degree of confidence in the values of the constants of the numerical formula which we shall presently determine. It is desired to remark further the interesting circumstance that this series of POND is the only one in astronomical annals which, taken alone, illustrates in a satisfactory way the existence of the seven-year cycle in the range of the latitude-variation. That it does this so perfectly, is in itself an index of the merit which must in future attach to this long-neglected series of observations.

To find the constants from the above observed values of $\Delta\varphi$, we put n and π equal to zero in eq. (28) so that (29) becomes

$$x_0 + y\sin\gamma + z\cos\gamma + \eta\sin\odot + \zeta\cos\odot = n$$

where the constant x_0 is of course an arbitrary unknown. Assuming in (25) the values $T_0' = 2389513$ and $\theta = 0^\circ.84$, we form equations of condition, using, for convenience, weights equal to one-tenth of the number of observations. Dividing the whole series into two exactly equal portions chronologically, we derive the following normal equations for the first half, 2387750–2389670, and for the second half, 2389730–2391650; or 1825.3–1830.6, and 1830.7–1836.0, respectively.

1825.3–1830.6.

$$\begin{array}{rrrrrcr}
+520.00\,x_0 & -21.61\,y & +64.42\,z & +111.51\,\eta & -53.38\,\zeta & = & -10''.37 \\
-21.61 & +251.19 & +14.25 & -148.76 & -68.31 & = & +18.26 \\
+64.42 & +14.25 & +268.51 & +87.81 & -124.88 & = & -19.11 \\
+111.51 & -148.76 & +87.81 & +277.72 & -7.85 & = & -21.78 \\
-53.38 & -68.31 & -124.88 & -7.85 & +242.28 & = & -23.79
\end{array}$$

1830.7–1836.0

$$\begin{array}{rrrrrcr}
+198.00\,x_0 & -5.05\,y & +42.54\,z & +18.99\,\eta & -43.84\,\zeta & = & +12''.56 \\
-5.05 & +103.34 & -8.56 & -29.84 & -9.14 & = & -3.32 \\
+42.54 & -8.56 & +94.66 & +31.12 & -38.12 & = & -3.77 \\
+18.99 & -29.84 & +31.12 & +88.84 & -5.34 & = & -3.79 \\
-43.84 & -9.14 & -38.12 & -5.34 & +109.16 & = & -13.41
\end{array}$$

The solution gives the unknowns and their probable errors:

	1825.3–1830.6		1830.7–1836.0	
	"	"	"	"
x_0	−0.0142		+0.0584	
y	+ .0203	±0.0132	− .0650	±0.0281
z	− .1398	± .0123	− .1167	± .0325
η	− .0225	± .0133	− .0450	± .0319
ζ	−0.1684	±0.0123	−0.1478	±0.0291

whence, by (30) and (25), we have for $\varphi - \varphi_0$,

$$\begin{array}{llll}
1825.3\text{–}30.6, & -0''.141\cos(t-2389503.1)\,0^\circ.84 & -0''.170\cos(\odot-\ 7.6) \\
 & \pm 0.012 \qquad\qquad\qquad\quad \pm\ 5.8 & \pm 0.012 \qquad\quad \pm\ 4.2 \\
1830.7\text{–}36.0, & -0.131\cos(t-2389547.8)\,0.81 & -0.155\cos(\odot-17.0) \\
 & \pm 0.032 \qquad\qquad\qquad\quad \pm 16.1 & \pm 0.029 \qquad\quad \pm 10.9
\end{array}$$

The probable errors of the coefficients are computed thus:

$$\text{For}\quad r_1 = \frac{1}{r_1}\left[y^2\varepsilon_1^2 + z^2\varepsilon_2^2\right]^{\frac{1}{2}}; \qquad \text{for}\quad T_1 = \frac{1}{\theta z\sin 1^\circ}\left[\sin^2(\theta\cdot\Delta T)\cos^2(\theta\cdot\Delta T)\varepsilon_1^2 + \cos^4(\theta\cdot\Delta T)\varepsilon_2^2\right]^{\frac{1}{2}}$$

$$r_2 = \frac{1}{r_2}\left[\eta^2\varepsilon_3^2 + \zeta^2\varepsilon_4^2\right]^{\frac{1}{2}} \qquad G = \frac{1}{\zeta\sin 1^\circ}\left[\sin^2 G\cos^2 G\,\varepsilon_3^2 + \cos^4 G\,\varepsilon_4^2\right]^{\frac{1}{2}}$$

where $\varepsilon_1, \varepsilon_2, \varepsilon_3, \varepsilon_4,$ are the probable errors of y, z, η, ζ.

The agreement of the two portions of the series is all that we could reasonably expect. Adding the normal equations, and solving for the whole series, we have,

$x_0 = +0''.007$, $y = -0''.0142 \pm 0''.150$, $z = -0''.1250 \pm 0''.0148$, $\eta = -0''.0145$, $\pm 0''.0156$, $\zeta = -0''.1668 + 0''.0146$

whence,

$$\begin{array}{ll}
\varphi - \varphi_0 = -0''.126\cos(t-2389520.7)\,0^\circ.84 & -0''.173\cos(\odot-14.9) \\
\qquad\qquad \pm 0.015 \qquad\qquad\qquad\quad \pm 8.0 & \pm 0.015 \qquad\quad \pm\ 4.9
\end{array} \qquad (49)$$

which is adopted as the result of this second approximation. A modification of the coefficients of the last term will result from the solution for the aberration-constant to be hereafter given. The values of $\varphi-\varphi_0$ in the last column of the foregoing table were computed from eq. (49).

From this investigation it will be remarked that the amplitudes of both terms of the variation are sensibly the same as those which prevail at the present time.

Two points remain to be examined. First, it is manifest that any error in the expansion-coefficient used in computing the refractions would produce a systematic variation in the declinations, and hence in the latitude, apparently dependent on the season of the year; and would have an opposite effect on stars north and south of the zenith. We therefore have a fine test of the existence of such an error, in the coefficients of the annual term of the latitude-variation derived independently from north and south stars. This test has been applied with the following results. The north and south stars being separated, the values of the 428-day term, by eq. (49), were subtracted from the observed values of $\Delta\varphi$, and solutions made to find η and ζ from each group. We thus have,

North stars, $\eta = -0''.0315, \quad \zeta = -0''.1744$
South stars, $\quad = -0.0535, \quad\quad = -0.1473$

and consequently the annual terms,

North stars, $0''.177 \cos(\odot - 10^\circ.2)$
South stars, $0.157 \cos(\odot - 19.9)$

The amplitude and epoch practically agree, and thus the conclusion on p. 4, no. 313, that no sensible error in the temperature-coefficient is to be feared, is satisfactorily confirmed.

Lastly, we have to examine the question spoken of on p. 3, concerning the effect of neglected errors of runs. It will be remembered that AIRY found evidence that in both of these instruments, this error was subject to a seasonal variation, although no numerical determination of the relation of the observed changes to actual changes of temperature was ever made, so far as I know. A similar dependence of error of runs on temperature was also distinctly shown by LAUGIER in the Gambey Mural Circle. In all three of these instruments the graduation was on the edge of the circle, and the microscopes were directed radially, which might naturally give rise to an error of this sort. If such an error exists it would tend to vitiate the coefficients of the annual term; hence it is vitally important to assure ourselves in the matter. We have a means of doing this which seems to me entirely satisfactory, even in the absence of any record of the errors of runs. A variation of runs dependent on temperature, and thence on season, must be directly proportional to the amount of the runs. If, therefore, we separate the stars into two classes comprising large and small runs, respectively, and find the constants of the annual term from each, their disagreement will show whether such an error exists to an appreciable amount. Since the constant G is, normally, somewhere near 0° for the Greenwich meridian, the epochs of minimum and maximum latitude for this term lie near the vernal and autumnal equinoxes, respectively. The extremes of temperature occur somewhat after the solstices. We should therefore anticipate that, if such an error existed, the value of G derived from stars with large runs would be thrown toward one of the solstices by an amount greater than that derived from stars with small runs. The coefficient r_2 would also be sensibly different. To apply this test I separated the stars according to amount of the runs, excluding of course those in which the pointer-readings changed during the series, or which had different pointer-readings on the two circles on account of difference of index-errors; in other words, the data were used only for stars in which the runs were simultaneously large or small for both circles during the whole interval. Correcting the observed values of $\Delta\varphi$ for the 428-day term, and solving for the annual term alone, we get,

Small runs, $\eta = -0''.0520, \quad \zeta = -0''.1633$
Large runs, $\quad = -0.0678, \quad\quad = -0.1906$

Consequently the annual terms become,

Small runs,	$0''.171 \cos(\odot - 17^\circ.7)$,	Average run, 1'.4
Large runs,	$0.202 \cos(\odot - 19.6)$,	" " 3.9

The differences are entirely within the uncertainty of the determinations. If we assume them to be entirely due to the error we are discussing, the proportional values, for Run = 0, give,

$$0''.154 \cos(\odot - 16^\circ.6)$$

the difference between which and the last term of (49) is insignificant. It therefore seems to me that we need not fear any vitiating influence of this sort upon the formula for latitude-variation found from POND's observations.

Another test, which bears on a collateral question, may be found from the probable errors of observation. From the discussion in the previous paper we find from stars with small and large runs, respectively, the value of r' for groups south and north of 30° declination,

	South	North	Mean by wts.
Small runs,	±0''.277	±0''.244	±0''.266
Large runs,	±0.294	±0.281	±0.287

The neglect of the errors of runs would therefore seem to have affected, by a moderate amount, the accidental error of observation.

The next matter to be presented is the aberration-constant, and the parallaxes of those stars for which the data appear to be reasonably determinate.

OBSERVATIONS OF VARIABLE STARS OF LONG-PERIOD, 1893-1894,

BY PAUL S. YENDELL.

893. *U Ceti.*

Ten observations of this star, from 1893 Nov. 30 to 1894 Jan. 8, indicate a maximum of $6^{M}.7$, on 1893 Dec. 25.

1574. *W Tauri.*

Twenty-three observations of *W Tauri*, from 1893 Dec. 4 to 1894 Mar. 19, indicate a maximum of about 8^{M} 1894 Feb. 10.

1582. *S Tauri.*

Seven observations, from 1893 Dec. 29 to 1894 Feb. 5, indicate, not very certainly, a maximum of about $9^{M}.8$ on 1894 Jan. 21. The star is very difficult of observation with my telescope.

1623. *T Camelopardalis.*

T Camelopardalis was first seen 1893 Sept. 13, at which observation it was estimated at $10^{M}.5$; my observations indicate a principal maximum of $8^{M}.1$ on 1893 Dec. 27; this was followed by a rapid decline to $8^{M}.6$ about 1894 Jan. 10, rising again to a second maximum of $8^{M}.25$, 1894 Jan. 23; a rapid decline followed this maximum, and on Feb. 9 a light of $9^{M}.0$ is indicated: an interval of bad observing weather prevented further observations until Mar. 1, when it was again found at $9^{M}.0$; this seems to agree with J. A. PARKHURST's third maximum of Feb. 19, as the star was fading at a rate of a magnitude in twenty days during late January and early February; the discordance between my magnitudes and Mr. PARKHURST's is probably due to the difference in the apertures employed, the star being very red.

1717. *V Tauri.*

From 1893 Dec. 27 to 1894 Mar. 7, I have fourteen observations of this star; a maximum of about $9^{M}.0$ is indicated on 1894 Jan. 31.

1805. *V Orionis.*

The observations of this star, which resulted in the confirmation of its variability, published in this Journal, XIII, p. 187, have been continued, and, up to Mar. 7, number twenty-four. It rose steadily and rapidly to a maximum of $8^{M}.4$, which is very sharply indicated on 1894 Jan. 13; this was thirty-four days after the date of the first observation; the decrease has been regular, though somewhat less rapid; and the star passed below the reach of my telescope, probably about sixty days after the maximum; the date of this, however, is not certain, as no observation was made from Mar. 7, when it was estimated at 10^{M}, to Mar. 23, when it is recorded as not seen, the limit of vision being assumed as $<11^{M}.0$.

The comparison-stars are

			DM.	Y
a	=	DM. +3°764	$9^{M}.4$	9.6
b	=	4 832	9.3	9.2
c	=	3 760	9.3	8.8
d	=	3 768	9.0	8.6
e	=	3 762	8.8	8.1

DEBALL's maximum of 1891, published in the current volume of this Journal p. 7, makes it possible to make a very fair estimate of the star's elements. The two Bonn observations in 1855 and 1856 are assumed to indicate a maximum occurring in the interval between them, as it seems very improbable that the star should have passed from $9^{M}.2$ to its minimum, certainly $<12^{M}$, and increased again to $9^{M}.2$ in the space of fifteen days; assuming that the Bonn estimate of magnitude is equivalent to $8^{M}.9$ on the scale of magnitudes in the column *Y*, the interval between its passing that brightness on its increase and again on its decrease, in my observed maximum given above, is from Jan. 1 to Jan. 29; and as a maximum seems likely to have taken place on 1856 Jan. 4, it is assumed for that date.

The period most nearly satisfying this maximum, with DEBALL's and my own, is one of 267 days; assuming DEBALL's maximum as the principal epoch, this period gives dates as follows:

−52	1856 Jan. 4
0	1891 Feb. 10
+ 4	1894 Jan. 13

By the use of these elements, the dates when I looked for the star unsuccessfully are accounted for as follows:

Date	Julian Date	Limit	E	Comp. Max.	$t-T$
1892 Jan. 1	2412098	$<11^{M}$	1	2412041	$+57^{d}$
Mar. 6	2412164	<10	1	"	+123
Mar. 19	2412177	<11	1	"	+136
Oct. 21	2412393	<11	2	2412308	+ 85
Nov. 11	2412414	<11	2	"	+106
Nov. 24	2412427	<11	2	"	+119
Dec. 9	2412442	<11	2	"	+134
1893 Feb. 5	2412500	<11.5	3	2412575	− 75
Nov. 30	2412798	11.5–12*	4	2412842	− 44

I would therefore suggest, as provisional elements:

$$E = 1891 \text{ Feb. } 10 = 2398954 \quad + 267^{d}\,E.$$

Using these elements, the computed maxima for the next two years are:

1894 Oct. 7 1895 July 2 1896 Mar. 24

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*Glimpsed.

1981. *S Camelopardalis.*

The observations of this star have been kept up as continuously as possible; and a minimum is indicated 1893 Oct. 27, at an estimated magnitude of $10^{M}.2$; this was followed by a rapid rise to a maximum of $8^{M}.3$, which is indicated on 1894 Feb. 22; on Mar. 16 it had fallen to $8^{M}.8$.

From a careful discussion of all the available data, the average period of the star appears to be, very closely, 292 days.

2258. *V Aurigae.*

I have seventeen observations of *V Aurigae*, extending from 1893 Oct. 12 to 1894 Mar. 7, on which latter date it was found to be invisible, the limit of vision at that time being assumed as $11^{M}.5$. These observations show no certain maximum; the star at the first mentioned date was estimated at $9^{M}.0$; at the next two observations, Oct. 15 and 18, it was rated only half a step brighter, and from the latter date it decreased steadily; the maximum, according to the elements in Chandler's Second Catalogue, would occur on Nov. 2; this date, however, is very uncertain, and the general indication of my observations is that the period assigned is too long by several days, as the maximum, in all probability, occurred before Oct. 12.

2742. *S Geminorum.*

Ten observations, from 1893 Dec. 26 to 1894 Feb. 5, indicate that this star passed a well-marked maximum of $8^{M}.4$ on 1894 Jan. 3; at the last observation its light was estimated as $9^{M}.4$.

Dorchester, Mass., 1894 *March* 28.

OBSERVATIONS OF COMET *a* 1894 (DENNING),

MADE AT THE DUDLEY OBSERVATORY,

BY LEWIS BOSS.

1894 Albany M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
March 27 8 58 31	1	10 , 9	−0 29.02	−1 10.9	9 59 4.09	+31 34 56.2	n8.931	0.235
29 12 3 36	2	11	+0 45.20	+6 16.7	10 6 45.24	+30 24 42.1	9.479	0.398
April 1 11 18 55	3	5	−4 4.89	−7 9.6	10 16 46.99	+28 47 40.7	9.338	0.382
6 13 4 54	4	16 , 8	+0 0.62	+5 4.8	10 32 14.42	+26 6 56.8	9.591	0.563
9 9 4 29	5	13	−0 55.85	−2 1.3	10 40 7.12	+24 40 16.5	n8.670	0.434

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	″	° ′ ″	s	
1	9 59 31.02	+2.09	+31 36 6.1	+1.0	Leiden A.G. Zones, 163 and 278
2	10 5 57.97	+2.07	+30 18 25.0	+0.4	Leiden A.G. Zones, 37 and 39
3	10 20 49.81	+2.07	+28 54 51.0	−0.7	W.B. X, 361, and comp. with W.B. X, 391
4	10 32 13.80	+1.98	+26 1 53.5	−1.5	W.B. X, 594, and comp. with BB.VI, 26°2119
5	10 41 1.01	+1.96	+24 42 20.1	−2.3	DM. 24°2269 comp. with B.B. VI, 24°2270

The above observations were made with the new Pruyn Equatorial of twelve inches aperture This telescope was made by Warner & Swasey, of Cleveland. the optical parts are by John A. Brashear of Allegheny, Penn. The position-micrometer was received at the Observatory on March 24; the arrangements for illumination are temporary, and the adopted value of a screw revolution, though probably near the truth, is provisional only. The chronograph has not yet been received; consequently the eye-and-ear method was employed in obtaining the foregoing observations.

The coordinates of the new Dudley Observatory are for the present assumed to be:

$$\lambda = 4^{h}\ 55^{m}\ 7^{s}.1\,; \quad \varphi = 42^{\circ}\ 39'\ 13''.$$

April 9. DM. 24°2269 — B.B. VI, 24°2270; $\Delta\alpha = -37^{s}.09$; $\Delta\delta = +10'\ 18''.3$. Comet observations difficult.

OBSERVATIONS OF COMET *a* 1894 (*DENNING*),

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

1894 Cincinnati M.T.	*	No. Comp.	☄ — *		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
March 29 8 23 57	1	8	+0 37.95	−11 40.0	10 6 21.02	+30 28 36.3	*n*9.219	0.183
8 23 57	2	8	+0 21.35	+10 16.5	10 6 21.39	+30 28 41.8		
30 8 28 36	3	1	−0 25.28	+ 5 28.8	10 9 50.10	+29 55 47.1	*n*9.195	0.187
8 28 36	4	8	−1 50.57	− 3 27.0	10 9 49.89	+29 55 45.0		

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	10 5 10.99	+2.08	+30 40 15.9	+0.4	Leiden A.G.Z., 2 obs.
2	10 5 57.97	+2.07	+30 18 25.0	+0.3	Leiden A.G.Z., 2 obs.
3	10 10 13.31	+2.07	+29 50 18.3	0.0	Leiden A.G.Z., 2 obs.
4	10 11 38.38	+2.08	+29 59 12.1	−0.1	Leiden A.G.Z., 2 obs; Bonn VI

FILAR-MICROMETER OBSERVATIONS OF COMET *a* 1894 (*DENNING*),

MADE AT THE HALSTED OBSERVATORY, PRINCETON, N.J., WITH 23-INCH TELESCOPE,

BY TAYLOR REED.

1894 Eastern Stand. Time	*	No. Comp.	☄ — *		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
h m s			s	′ ″	h m s	° ′ ″		
March 27 11 20 25	1	. .	− 6.53	−4 36.1	9 59 26.55	+31 31 31.0	. .	. .
30 10 58 0	2	10.10	−10.30	+3 7.5	10 10 5.50	+29 53 25.7	9.262	0.249
April 6 11 15 20	3	4	. . .	−1 55.9	. . .	+26 40 42.3	. .	0.378
11 56 0	3	4	+19.66	. . .	10 29 13.25	. . .	9.474	. .

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	9 59 30.99	+2.087	+31 36 6.1	+0.98	Leiden A.G.Zone 163,126.
2	10 10 13.29	+2.052	+29 50 18.3	−0.12	Leiden A.G.Zone 237,67; 239,66.
3	10 28 51.59	+1.995	+26 42 39.8	−1.59	Paris 12944

The observation of March 27 is uncorrected for refraction. "Eastern Standard Time" is 5h slow of Greenwich M.T.

OBSERVATIONS OF COMET *a* 1894,

MADE AT THE OBSERVATORY OF THE CATHOLIC UNIVERSITY, WASHINGTON, D.C.

BY REV. G. M. SEARLE.

1894 Greenwich M.T.	*	No. Comp.	☄ — *		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
April 2 15 51 56	1	4	−4 9.69	− 6 8.2	10 19 55.74	+28 15 56.9	9.190	0.244
15 51 56	2	4	−1 27.25	− 8 41.2	10 19 55.50	+28 15 56.3	"	"
3 14 47 56	3	6	+0 50.00	+ 1 2.9	10 22 54.14	+27 46 14.7	*n*8.735	0.231
4 14 29 47	4	5	+3 3.88	−13 12.7	10 25 55.48	+27 14 13.7	*n*8.394	0.248

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	10 24 3.37	+2.06	+28 22 6.0	−0.9	W.B. X, 439
2	10 21 20.70	+2.05	+28 24 41.1	−0.6	B.B. VI. 28°1879
3	10 22 2.12	+2.02	+27 45 12.6	−0.8	W.B. X, 386
4	10 22 49.60	+2.00	+27 27 57.2	−0.8	Lalande 20291

COMETS OF THE YEAR 1893.

The dates are in Greenwich Mean Time, and the Elements only approximate.

Designation	Perihelion	☊	ω	*i*	*q*	φ	Discoverer	Date	Synonym	
		° ′	° ′	° ′		° ′				
I	Jan. 6.496	185 38	85 13	143 52	1.1951	–	Brooks	1892 Nov. 19	*g* 1892	
II	July 7.283	337 20	47 8	159 58	0.6746	–	Naked eye	–	*b* 1893	
III	July 12.182	52 28	315 14	3 2	–	46 1	Finlay	1893 May 17	*a* 1893	Periodic
IV	Sept. 19.268	174 54	347 33	129 48	0.8135	–	Brooks	Oct. 16	*c* 1893	

COMET *b* 1894.

A comet was discovered by Gale at Sydney, N.S.W., in the position

1894 April 2.944 Greenwich M.T. $\alpha = 2^h\ 30^m\ 48^s$, $\delta = -55°\ 38'$.

It is round and bright, with condensation.

COMET *c* 1894.

A bright comet, with tail, was discovered by Holmes at London, in the roughly approximate position

1894 April 9.5 Greenwich M.T. $\alpha = 17^h\ 58^m$, $\delta = +71°\ 30'$.

NEW ASTEROID.

Prof Kreutz announces that a new planet has been discovered by Bigourdan at Paris.

BC 13^M March 24 $10^h\ 26^m.0$ Paris M.T. $\alpha = 9^h\ 24^m\ 56^s$; $\delta = +4°\ 12'$. Daily motion, -60^s in α, $0'$ in δ.

NOTICE.

Prof. Van de Sande Bakhuyzen asks that any unpublished observations of the variable star 6794 *R Lyrae*, made during the years 1880–1882, may be made public, or communicated to Mr. A. Pannekock of the Leiden Observatory, who is engaged in the study of that star.

CORRIGENDA.

No. 314, p. 13, Obs. of *R Trianguli*, *for* Dec. 12, *put* Dec. 21. | No. 314, p. 13, Comp.-Star for *S Lacertae*, *for* *O* *put* *Q*.

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Corrigenda.

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THE SECULAR PERTURBATIONS OF *URANUS* ARISING FROM THE ACTION OF *NEPTUNE*, DETERMINED BY THE METHOD OF GAUSS.

By T. J. J. SEE.

The celebrated method discovered by GAUSS, in 1818, for determining secular perturbations by finding the attraction of a certain form of elliptical ring which will give the same mean action as the moving planet, has been fully developed by Dr. G. W. HILL in his important Memoir on "GAUSS'S *Method of Computing Secular Perturbations*" (*Astronomical Papers prepared for the use of the American Ephemeris*, Vol. I, 1882). M. CALLANDREAU has supplemented this work of HILL by a valuable paper entitled "*Calcul des Variations Séculaires des Éléments des Orbites*" (*Annales de l'Observatoire de Paris.* Tome XVIII, 1885).

Both of these Memoirs emphasize the superior advantages of the method of GAUSS, which involves the use of elliptic integrals of the first and second kinds; and since no great number of applications of the method appears as yet to have been made, it may not be without interest to determine in this manner the Secular Perturbations of *Uranus* depending upon the action of *Neptune*.

If it were desired to determine the secular variations for all time, it would of course be necessary to use the absolute mean elements, which are independent of the long-period inequalities; but owing to the uncertainty still attaching to the elements of *Neptune*, and the masses of the two planets, this would at present be quite impracticable. And since our object is rather to determine the secular variations which are going on in the heavens at the present time, it is necessary to employ the elements of *Uranus* and *Neptune* as corrected for the 4000-year inequality, which for a similar reason have been adopted in HILL'S "*New Theory of Jupiter and Saturn*" (p. 109; 161). Hence the elements of *Uranus* and *Neptune* employed in the present research are those found by NEWCOMB in his investigations of the orbits of these planets (*Smithsonian Contributions to Knowledge*, No. 199, p. 76; No. 262, p. 181); but on the suggestion of Dr. HILL, the mass of *Uranus* has been diminished to $\frac{1}{22800}$, which is the value now accepted. The elements of NEWCOMB, with the modern mass of *Uranus*, are as follows:

$$
\begin{array}{lrrr|lrrr}
\multicolumn{4}{c|}{\textit{Uranus.}} & \multicolumn{4}{c}{\textit{Neptune.}} \\
 & {}^\circ & {}' & {}'' & & {}^\circ & {}' & {}'' \\
L = & 28 & 25 & 17.05 & L' = & 335 & 5 & 38.91 \\
\pi = & 168 & 15 & 6.7 & \pi' = & 43 & 17 & 30.3 \\
\Omega = & 73 & 14 & 8.0 & \Omega' = & 130 & 7 & 31.83 \\
i = & 0 & 46 & 20.54 & i' = & 1 & 47 & 1.68 \\
e = & \multicolumn{3}{l|}{0.0469236} & e' = & \multicolumn{3}{l}{0.0084962} \\
n = & \multicolumn{3}{l|}{15425''.752} & n' = & \multicolumn{3}{l}{7864''.935} \\
m = & \multicolumn{3}{l|}{\frac{1}{22800}} & m' = & \multicolumn{3}{l}{\frac{1}{19700}} \\
\log a = & \multicolumn{3}{l|}{1.2831044} & \log a' = & \multicolumn{3}{l}{1.4781414}
\end{array}
$$

Epoch 1850.0, Greenwich Mean Time.

The calculation of the auxiliary constants has been throughout very carefully checked, and it is hardly possible that there can remain any sensible error in the result. Using the notation of HILL, we find

$$
\begin{array}{lrrr|ll}
 & {}^\circ & {}' & {}'' & & \\
I = & 1 & 30 & 27.73 & \log \kappa = & 9.9999853 \\
\Pi = & 12 & 43 & 24.93 & \log \kappa' = & 9.9999976 \\
\Pi' = & 247 & 45 & 12.27 & \log C = & 8.8147322 \\
K = & 124 & 58 & 15.51 & C = & 0.0652728 \\
K' = & 124 & 58 & 9.81 & &
\end{array}
$$

Dividing the circumference of the orbit of *Uranus* into 12 parts with respect to the eccentric anomaly E, we have computed the values of the functions given in the accompanying tables. The computations are checked at the bottom of the columns, where Σ_1 and Σ_2 denote respectively the sums of the 1st, 3d, 5th, etc., and of the 2d, 4th, 6th, etc., tabular numbers. An inspection of the tables will show that the agreement is in all cases very satisfactory. If we divide the numbers at the bottom of the last five columns $(\Sigma_1+\Sigma_2)$ by 12, we shall get by simple quadrature the average values of the several tabulated functions, which are the well-known expressions entering the differential coefficients of the elements. We find

$$\left[\frac{da}{dt}\right]_{00} = 0$$

$$\left[\frac{de}{dt}\right]_{00} = \quad -42''.03144\,m'$$

$$\left[\frac{d\chi}{dt}\right]_{00} = +8787''.847\,m'$$

$$\left[\frac{di}{dt}\right]_{00} = \quad -212''.8323\,m'$$

$$\left[\frac{d\Omega}{dt}\right]_{00} = +2307''.319\,m'$$

$$\left[\frac{d\pi}{dt}\right]_{00} = +8788''.056\,m'$$

$$\left[\frac{dL}{dt}\right]_{00} = -7264''.147\,m'$$

where the mass of *Neptune* is left indefinite. If we use the mass of *Neptune* found by Newcomb, which is $\frac{1}{19700}$, we shall obtain, for the secular variations per Julian year, the following numerical values:

$$\left[\frac{de}{dt}\right]_{00} = -0''.002133575$$

$$\left[\frac{d\chi}{dt}\right]_{00} = +0''.4460836$$

$$\left[\frac{di}{dt}\right]_{00} = -0''.01080367$$

$$\left[\frac{d\Omega}{dt}\right]_{00} = +0''.1171228$$

$$\left[\frac{d\pi}{dt}\right]_{00} = +0''.4460942$$

$$\left[\frac{dL}{dt}\right]_{00} = -0''.3687385$$

Assuming the mass of *Neptune* to be $\frac{1}{14400}$, LeVerrier has given (*Annales de l'Observatoire de Paris*, Tome XI, p. 86–88) the following values, deduced from the series expanded in powers of the eccentricities and mutual inclination of the planes of the orbits:

$$\left[\frac{de}{dt}\right]_{00} = -0''.003911$$

$$\left[\frac{d\chi}{dt}\right]_{00} = +0''.60819$$

$$\left[\frac{di}{dt}\right]_{00} = -0''.014787$$

$$\left[\frac{d\Omega}{dt}\right]_{00} = +0''.15778$$

$$\left[\frac{d\pi}{dt}\right]_{00} = +0''.60820$$

$$\left[\frac{dL}{dt}\right]_{00} = -0''.50397$$

The secular variation of the longitude of the epoch is given by LeVerrier in Tome XIII, p. 168.

The coefficient $\left[\frac{d\pi}{dt}\right]_{00}$ was not stated by LeVerrier, but has been derived by the writer from the preceding values by means of the usual formula and the elements employed by LeVerrier, which are as follows:

Uranus.	*Neptune.*
$e = 9607''.30$	$e' = 1798''.53$
$\varpi = 168°\ 16'\ 45''.0$	$\varpi' = 47°\ 14'\ 37''.3$
$i = 0\ \ 46\ \ 29\ .91$	$i' = 1\ \ 46\ \ 58\ .97$
$\Omega = 73\ \ 14\ \ 14\ .4$	$\Omega' = 130\ \ 6\ \ 51\ .6$

Epoch 1850.0.

As the mass of *Neptune* used by LeVerrier was about 37 per cent. larger than that here employed, it is evident that his differential coefficients should be diminished by about this amount in order to make them comparable with the values found above. We also see that LeVerrier's elements do not exactly agree with those assumed here, and hence it is probable that the remaining differences are due to differences in the elements employed, or to the degree of approximation to which his calculation was extended.

E	log r	v	A	ε	log B	log g
°		° ′ ″		° ′ ″		
0	1.2622321	0 0 0	1233.434	124 18 34.44	2.7369001	4.1224970
30	1.2650873	31 22 22.27	1234.602	156 1 10.26	2.7376693	3.5080326
60	1.2727937	62 21 25.03	1245.967	187 25 38.25	2.7450069	2.5277276
90	1.2831044	92 41 22.24	1264.781	218 7 49.00	2.7566374	3.9092128
120	1.2931761	122 18 8.17	1286.152	247 57 49.42	2.7691393	4.2871200
150	1.3004037	151 19 5.32	1304.204	277 1 0.04	2.7791714	4.3665454
180	1.3030194	180 0 0	1313.807	305 33 48.00	2.7843265	4.2040716
210	1.3004037	208 40 54.68	1312.230	333 58 24.12	2.7834925	3.6662272
240	1.2931761	237 41 51.83	1300.053	2 37 58.31	2.7769100	1.6928580
270	1.2831044	267 18 37.76	1280.834	31 52 38.25	2.7660966	3.7923606
300	1.2727937	297 38 34.97	1259.869	61 55 27.43	2.7536593	4.2133094
330	1.2650873	328 37 37.73	1242.629	92 48 14.31	2.7428748	4.2994412
Σ_1	. . .	. . .	7639.282	929 49 15.85	6.5659421	. . .
Σ_2	. . .	. . .	7639.280	1109 49 15.98	6.5659420	. . .

E	h	l	G	G'	G''	θ
0°	904.1990	329.1695	904.1735	329.2395	0.0445383	37° 7′ 5.25″
30	904.1989	330.3372	904.1920	330.3549	0.0107843	37 11 22.88
60	904.2162	341.6857	904.2155	341.6874	0.0010910	37 55 51.08
90	904.2329	360.4829	904.2164	360.5243	0.0248889	39 9 26.29
120	904.2391	381.8476	904.1990	381.9447	0.0560862	40 32 18.94
150	904.2282	399.9102	904.1772	400.0255	0.0642991	41 41 44.91
180	904.2176	409.5240	904.1818	409.6028	0.0431969	42 18 18.67
210	904.2046	407.9606	904.2036	407.9835	0.0125696	42 12 1.33
240	904.2154	395.7719	901.2153	395.7721	0.0001377	41 25 15.56
270	904 2337	376.5349	904.2207	376.5661	0.0182073	40 11 28.59
300	904.2312	355.5728	904.1983	355.6566	0.0508177	38 50 36.44
330	904.2169	338.3469	904.1780	338.4510	0.0651166	37 43 25.15
Σ_1	5425.3185	2213.5715	5425.1834	2213.9031	0.1958678	238 9 28.94
Σ_2	5425.3152	2213.5727	5425.1879	2213.9053	0.1958658	238 9 29.15

E	$\log \mathfrak{K}$	$\log \mathfrak{L}'$	$\log \mathfrak{N}$	$\log N$	$\log P$	$\log Q$	$\log V$
0°	0.15164665	0.47034123	0.39644965	9.5248055	4.0826005	6.9649820	6.9649566
30	0.15229788	0.47116899	0.39736543	9.5311781	4.0898153	6.9722776	6.9722714
60	0.15915897	0.47988018	0.40700954	9.5534421	4.1207773	7.0041791	7.0041785
90	0.17093687	0.49479346	0.42350271	9.5858238	4.1680489	7.0530423	7.0530282
120	0.18490107	0.51240954	0.44295677	9.6199214	4.2197491	7.1065873	7.1065557
150	0.19718862	0.52785261	0.45998576	9.6466738	4.2619576	7.1503752	7.1503391
180	0.20388324	0.53624396	0.46922874	9.6586117	4.2823026	7.1715639	7.1715397
210	0.20272048	0.53478763	0.46762523	9.6522240	4.2744672	7.1635770	7.1635699
240	0.19422059	0.52412728	0.45588006	9.6292695	4.2408532	7.1288778	7.1288778
270	0.18131918	0.50789763	0.43797703	9.5962076	4.1915388	7.0779014	7.0778912
300	0.16786708	0.49091135	0.41921146	9.5621268	4.1404619	7.0250502	7.0250214
330	0.15721514	0.47741398	0.40427997	9.5360663	4.1009099	6.9840611	6.9840241
Σ_1	1.06167760	3.01391354	2.59073622	7.5481770	5.0867446	2.4012403	2.4011297
Σ_2	1.06167817	3.01391430	2.59073612	7.5481736	5.0867377	2.4012346	2.4011269

E	$\log J_1$	$\log J_2$	$\log J_3$	$\log F_2$	$\log F_3$	$\log R_0$	$\log S_0$
0°	2.9562584	0.5675757	0.7077489	n3.5393572	n1.9278475	9.2912445	n6.8916885
30	2.9561018	0.1971495	1.2038825	n3.2321250	n1.4904951	9.2972477	n6.7934509
60	2.9559712	n9.8843134	1.3533713	2.7419725	0.5625334	9.3215929	n5.6485440
90	2.9559842	n0.4525539	1.3627156	3.4327151	n1.2773921	9.3584836	6.8948119
120	2.9561278	n0.6350081	1.2388812	3.6216687	n1.9015838	9.3984384	7.1540282
150	2.9562598	n0.6907277	0.8410835	3.6613814	n2.0817730	9.4303739	7.1603209
180	2.9562578	n0.6375570	n0.7287171	3.5801445	n2.0094221	9.4447895	6.9253983
210	2.9561262	n0.4107610	n1.2106868	3.3112223	n1.6237710	9.4373780	5.9975631
240	2.9559846	8.5564550	n1.3582100	n2.3245377	0.2798454	9.4106660	n6.5040067
270	2.9559688	0.4355171	n1.3674640	n3.3742890	n1.0355820	9.3727092	n6.6215902
300	2.9561014	0.6589839	n1.2451710	n3.5847634	n1.8059711	9.3341121	n6.6821020
330	2.9562622	0.6887818	n0.8566133	n3.6278293	n2.0065489	9.3046472	n6.8109588
Σ_1	7.7367012	. . . .	. . . .	. . . .	. . . .	6.2008434	+0.000643966
Σ_2	7.7367030	. . . .	. . . .	. . . .	. . . .	6.2008396	+0.000643850

E	$\log W_0$	$R_0 \sin v+$ $S_0 (\cos v+\cos E)$	$-R_0 \cos v+$ $S_0\left(\frac{n}{a\cos^2\varphi}+1\right)\sin v$	$W_0 \cos u$	$W_0 \sin u$	$-2\frac{r}{a}R_0$
0°	7.6631491	−0.0015585	−0.1955440	−0.00040258	+0.00458651	−0.3727357
30	8.1750511	+0.1021492	−0.1699135	−0.00887792	+0.01204621	−0.3804176
60	8.3576418	+0.1857185	−0.0973695	−0.02103091	+0.00876584	−0.4095550

E	$\log W_0$	$R_0 \sin v + S_0 (\cos v + \cos E)$	$-R_0 \cos v + S_0 \left(\frac{n}{a \cos^2 \varphi} + 1\right) \sin v$	$W_0 \cos u$	$W_0 \sin u$	$-2 \frac{r}{a} R_0$
90°	8.4152785	+0.2280000	+0.0122819	−0.02578332	−0.00348871	−0.4565765
120	8.3428369	+0.2100781	+0.1361909	−0.01751279	−0.01335014	−0.5123186
150	7.9815365	+0.1267686	+0.2377495	−0.00384690	−0.00877782	−0.5606647
180	*n*7.9108239	−0.0016843	+0.2784771	−0.00071208	+0.00811255	−0.5830884
210	*n*8.3757056	−0.1315657	+0.2400761	−0.01317819	+0.01976124	−0.5697801
240	*n*8.4870409	−0.2172635	+0.1381156	−0.02727788	+0.01407069	−0.5269479
270	*n*8.4456178	−0.2356104	+0.0119056	−0.02787787	−0.00113275	−0.4717797
300	*n*8.2722482	−0.1916579	−0.0992939	−0.01575816	−0.01010078	−0.4215328
330	*n*7.8485921	−0.1061047	−0.1715269	−0.00313279	−0.00632301	−0.3869546
Σ_1	−0.00814422	−0.0163676	+0.1605762	−0.08269440	+0.01208467	−2.8261784
Σ_2	−0.00814355	−0.0163670	+0.1605727	−0.08269699	+0.01208517	−2.8261732
$\Sigma_1 + \Sigma_2$	. . .	−0.0327346	+0.3211489	−0.16539139	+0.02416984	−5.6523516

The University of Chicago, 1894 *March* 15.

ON THE ELEMENTS OF THE VARIABLE STAR *Y CYGNI*,

By N. C. DUNÉR.

In no. 312 of the *Astronomical Journal*, Mr. YENDELL has published an important series of observations, as well of even as of uneven minima of this star. Mr. YENDELL has also compared his observations with the elements in CHANDLER'S last Catalogue of Variable Stars, and found very considerable discordances between observation and computation. Yet a closer examination of Mr. YENDELL'S communication shows that in the comparison of the observations, he has taken no account of the discordance which I have found in the periods for the even and uneven minima, possibly resulting from a revolution of the line of apsides.

I have consequently made a new comparison of the observations with the ephemeris in the *Vierteljahrsschrift der Astronomischen Gesellschaft*, deduced from my last elements, and have found the following discordances between observations and computations:

I EVEN EPOCHS

E	O−C (^{m})
E=1562	O−C=+ 38.0
1570	− 1.5
1598	− 10.2
1612	+ 2.0
1626	+ 55.6
1628	[+102.7]
1634	+ 56.1
1636	+ 69.2
1644	+ 48.5
1646	+ 18.5
1648	+ 19.5
1666	+ 8.6
1668	+ 38.4
1670	+ 64.3
1672	+ 35.3
1674	+ 45.1
1682	+ 6.3
1688	+ 16.7

II UNEVEN EPOCHS

E	O−C (^{m})
E=1623	O−C=− 86.7
1625	− 96.3
1637	− 76.6
1651	[−140.7]
1677	− 78.9
1679	− 92.6

A glance at these discordances shows that it would not be easily possible to do away with them by any probable change in the elements, even if the bracketed discordances were rejected. At the same time, however, some improvement in the elements seems to be requisite. I have therefore combined these discordances in the manner shown by the lines, and have thus formed the following new normal-minima.

E	Normal-minimum
1586	2719^d.666
1640	2800.596
1649	2813.737
1674	2851.526

In the same way as in my paper "*Sur les Éléments de l'Étoile Variable Y Cygni*," pp. 131, 2, an even or uneven number, for the epoch of the normal-minimum, signifies that the same is formed of even or uneven minima respectively. In order to be able to employ my earlier computations in the farther discussion, I have also compared these normal-minima with the original elements,

$$\text{Min. } 1886.0 \;+343^d.4749 \;+1^d.498124\, E \text{ (Paris M.T.)}$$

and thence found the following new equations of condition.

EVEN EPOCHS

$$dE_0 + 1586\, dP = +0^d.167$$
$$dE_0 + 1640\, dP = +0.198$$
$$dE_0 + 1674\, dP = +0.192$$

UNEVEN EPOCHS

$$dE_0 + 1649\, dP = -0^d.144$$

By comparison of these equations with those given on p. 330 of my paper I have obtained for the elements the following corrections:

$$dE_0 = -0^d.0026, \quad dP = +0^d.000112$$
$$dE_0 = -0^d.0538, \quad dP = -0^d.000030$$

For comparison I also quote those given in my treatise.

$$dE_0 = +0^d.0078, \qquad dP = +0^d.000097$$
$$dE_0 = -0^d.0659, \qquad dP = -0^d.000011$$

From these we obtain the following elements:

Even epochs, $\text{Min.} = 1886 + 343^d.4723 + 1^d.498236\,E$ (Paris M.T.)

Uneven epochs, $\text{Min.} = 1886 + 343^d.4211 + 1^d.498094\,E$ (Paris M.T.)

The residual errors are

E	O—C	E	O—C
12	$-0^d.005$	1191	$-0^d.008$
175	−0.014	1192	−0.004
211	−0.014	1211	−0.010
420	+0.028	1252	−0.007
689	+0.026	1297	+0.016
721	−0.006	1320	+0.005
[952]	[−0.097]	1586	−0.008
1062	−0.005	1640	+0.017
1148	−0.018	1649	−0.041
1165	+0.048	1674	+0.007
1176	−0.011		

As is natural, the magnitude of the errors becomes somewhat increased, although not to any considerable extent. If we now investigate how far the latest observations have increased our knowledge of this star, we shall find that, very far from refuting my hypotheses regarding the cause of the change of brightness, they have confirmed it throughout. The general character of the star-system was indeed already to be regarded as fully proved. Now it is also well established that the errors become intolerably large unless we assume some change, more or less of the same nature as a revolution in the line of apsides. In fact, the latest observations of Mr. Yendell require a still larger difference between the periods of the even and uneven epochs. By the investigation now made this difference is increased to the considerable amount of $12^s.5$, instead of $9^s.3$; and, if we employ the form given on p. 332 of my treatise, even to $25^s.0$, instead of $18^s.7$.

As regards the accuracy with which future minima can be computed in advance, this must not be estimated too high. Certainly, the periodic time of the components of the system is already determined very sharply; for the new computation has altered this by only a small fraction of a second. Yet, on the other hand, the amount of motion of the line of apsides (if we adopt this view of the phenomenon) is not determined very accurately, and moreover must soon change its value. I have therefore not deemed it necessary as yet to collect the observations which may perhaps have been made very recently in Europe.

But in order to form some idea as to the accuracy of the ephemeris for this year given in the *Vierteljahrsschrift*, I have computed the minimum, for June 1, with the new elements. Judging from this, we must assume that the uneven minima will occur about half an hour earlier.

It will be impossible to observe the star here, on account of the bright nights; yet it is much to be wished that the star be very assiduously observed in middle or southern Europe. The uneven minima of Mr. Yendell give, namely, a somewhat striking deviation from computation; it would therefore be very desirable that this should be confirmed or corrected independently. The ephemeris will, at any rate, be more than sufficient for due preparation for the observations.

Upsala, 1894 *March* 30.

OBSERVATIONS OF COMETS,

MADE WITH THE 16-INCH EQUATORIAL AND FILAR MICROMETER OF GOODSELL OBSERVATORY, AT NORTHFIELD, MINN.,

By H. C. WILSON.

[Communicated by Wm. W. Payne, Director.]

1894 Northfield M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			Comet 1893 IV (Brooks).					
Jan. 6 $8^h\ 1^m\ 59^s$	1	6, 4	$+8^m\ 12^s.45$	$-8'\ 11''.4$	$21^h\ 19^m\ 18^s.38$	$+73^\circ\ 29'\ 14''.1$	0.171	0.166
			Comet *a* 1894 (Denning).					
Mar. 28 9 30 50	2	15, 6	+ 0 32.13	− 7 35.6	10 3 1.58	+30 59 19.5	*n*8.336	0.308
29 9 25 41	3	2, 2	− 5 57.60	+ 5 29.3	10 6 34.81	+30 26 30.9	*n*8.595	0.335
9 25 41	4	2, 2	− 7 29.50	+ 2 54.5	. . .	. . .	. . .	. . .
9 25 41	5	2, 2	− 9 31.85	+ 3 46.9	. . .	. . .	. . .	. . .
9 25 41	6	2. 2	−10 55.85	+ 3 24.6	10 6 35.14	+30 26 29.6	*n*8.595	0.335
Apr. 1 14 10 19	7	9, 6	+ 1 50.35	+10 6.3	10 17 20.42	+28 42 19.9	9.651	0.635
5 8 45 0	8	3, 3	+ 0 5.70	− 0 18.2	10 28 59.17	+26 42 17.0	*n*8.977	0.436

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	21 11 11.39	−5.46	+73 37 16.5	+9.0	B.B. II, Zone 32, no. 10
2	10 2 27.37	+2.08	+31 6 54.2	+0.9	Micr.-comp. with Leid. Z. 286,72, & Bruss. 4207
3	10 12 30.31	+2.10	+30 21 1.7	−0.1	Lalande 19982
4	10 14 3.	. . .	+30 23.5	. . .	Anonymous
5	10 16 5.	. . .	+30 22.7	. . .	Anonymous
6	10 17 28.87	+2.12	+30 23 5.5	−0.5	Leiden A.G.Z. 275. 5
7	10 15 28.02	+2.04	+28 32 18.8	−0.2	B.B. VI, 28°1872
8	10 28 51.47	+2.00	+26 42 36.5	−1.3	Lalande 20460

Jan. 6. Comet *c* was invisible in the 5-inch finder, and very faint in the 16-inch. There was a small condensation in the center, surrounded by very diffuse nebulosity about 2′ in diameter.

Jan. 26. A very faint glow was found in the ephemeris place of Brooks's comet, too faint to measure. Holmes's comet was looked for, but no trace found.

March 28. Comet *a* 1894 is small, but quite bright for its size. It has a well-defined nucleus of about 11 magnitude, and a tail 2′ long. Scarcely visible in the 5-inch.

March 29. Position-angle of tail 164°.0 ; length 3′; width 1′. Nucleus 12M.

April 1. Position-angle 170°.2.

April 5. Comet so close to a bright star that at first it was not noticed. R.A. and Decl. measured directly with micrometer through breaks in clouds.

OBSERVATIONS OF COMET *a* 1894 (DENNING),

MADE AT THE CINCINNATI OBSERVATORY

By J. G. PORTER.

1894 Cincinnati M.T.	*	No. Comp.	☄ — *		☄'s apparent		log *p*Δ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Mar. 29 8 23 57	1	8	+0 37.95	−11 40.0	10 6 21.02	+30 28 36.3	*n*9.219	0.183
8 23 57	2	8	+0 21.35	+10 16.5	10 6 21.39	+30 28 41.8	*n*9.219	0.183
30 8 28 36	3	4	−0 25.28	+ 5 28.8	10 9 50.10	+29 55 47.1	*n*9.195	0.187
8 28 36	4	8	−1 50.57	− 3 27.0	10 9 49.89	+29 55 45.0	*n*9.195	0.187
Apr. 1 8 18 53	5	8	−0 15.55	+ 0 37.5	10 16 29.14	+28 50 59.3	*n*9.231	0.239
2 7 54 19	6	8	−2 15.42	+ 2 43.8	10 19 39.42	+28 19 20.3	*n*9.342	0.287
4 8 34 38	7	8	+0 49.04	+ 0 46.7	10 25 55.43	+27 14 35.7	*n*9.109	0.276
12 14 28 35	8	12	−0 42.10	− 1 0.5	10 48 32.29	+23 3 36.5	9.685	0.652

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	10 5 40.99	+2.08	+30 40 15.9	+0.4	Leiden A.G.Z., 2 obs.
2	10 5 57.97	+2.07	+30 18 25.0	+0.3	Leiden A.G.Z., 2 obs.
3	10 10 13.31	+2.07	+29 50 18.3	0.0	Leiden A.G.Z., 2 obs.
4	10 11 38.38	+2.08	+29 59 12.1	−0.1	Leiden A.G Z., 2 obs., Bonn VI, 30°1986
5	10 16 42.64	+2.05	+28 50 22.2	−0.4	Bonn VI, 29°2037
6	10 21 52.79	+2.05	+28 16 37.3	−0.8	Cincin. M.C., 2 obs. [12792
7	10 25 4.38	+2.01	+27 13 50.0	−1.0	Cincin. M.C., 1 obs., and eq. comp. with Paris
8	10 49 12.44	+1.95	+23 4 40.1	−3.1	Eq.comp. with Bonn VI, 23°2275, Paris 13380, [Berl. A.G.Z., 3 obs.

MERIDIAN-CIRCLE OBSERVATIONS OF COMPARISON-STARS,

MADE AT LICK OBSERVATORY, MT. HAMILTON,

By R. H. TUCKER, Jr.

The stars used for comparison with Comet 1893 II, on July 11, 12 and 13,* have been observed with the meridian circle, the epoch of observation being 1894.22.

The following are the mean places for 1894.0, with the corresponding precessions.

	α	Prec.	δ	Prec.
	h m s	s	° ′ ″	″
W. Bessel IX, 56	9 6 22.73	+3.967	+44 44 45.3	−14.57
" IX, 749	9 37 27.77	+3.787	+42 32 16.9	−16.30
" IX, 1204	9 59 32.98	+3.637	+40 5 50.2	−17.35

The second star differs by −4″ in declination, from Bessel's place.

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* *Astronomical Journal*, No. 301.

FILAR-MICROMETER OBSERVATIONS OF COMET *a* 1894 (*DENNING*),

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY,

BY E. E. BARNARD.

1894 Mt. Hamilton M.T.	✱	No. Comp.	☄ — ✱ $\Delta\alpha$	☄ — ✱ $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
March $30^d\ 11^h\ 22^m\ 3^s$	1	9 , 6	$+0^m\ 20^s.12$	$-1'\ 49''.1$	$10^h\ 10^m\ 38^s 84$	$+29^\circ\ 48'\ 30''.5$	9.029	0.064

Mean Place for 1894.0 of Comparison-Star.

✱	α	Reduction	δ	Reduction	Authority
1	$10^h\ 10^m\ 13^s.65$	$+2^s.07$	$+29^\circ\ 50'\ 19''.6$	0.0	Grant 2658, W.B. X, 161

About 11^M–12^M. 1′ diameter. Indefinite and very faint nucleus in n.p. part. Feeble brushing out s.f.

The comet was observed March 29 through clouds, but the comparison-star, 11^M, has not been identified yet. Cloudy weather prevented earlier observations.

OBSERVATIONS OF COMET *a* 1894 (*DENNING*),

MADE AT THE DUDLEY OBSERVATORY,

BY LEWIS BOSS.

1894 Albany M.T.	✱	No. Comp.	☄ — ✱ $\Delta\alpha$	☄ — ✱ $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			m s	′ ″	h m s	° ′ ″		
April 25 12 35 54 (h m s)	6	10 , 5	−2 42.92	+13 57.3	11 17 23.75	+17 16 12.8	9.565	0.658
26 10 35 39	7	18 , 6	+0 5.98	− 0 23.8	11 19 14.88	+16 53 42.6	9.270	0.600

Mean Places for 1894.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
6	11 20 4.82	+1.85	+17 2 20.8	−5.3	81 *Leonis*; p.m., $-0^s.010$, 0″.00
7	11 19 7.06	+1.84	+16 54 11.6	−5.2	DM. 17°2355, compared with ✱6

Though the comet appeared faint on April 25 and 26, the central condensation was sufficiently definite to permit of fairly accurate measures in $\Delta\delta$. The observations were made with illuminated threads.

April 26, DM. 17°2355 —81 *Leonis*: $\Delta\alpha = -0^m\ 57^s.77$; $\Delta\delta = -8'\ 9''.1$.

ELEMENTS AND EPHEMERIS OF COMET *a* 1894 (*DENNING*),

BY LEWIS BOSS.

From observations made at the Dudley Observatory March 27, April 6, April 9 and April 26, the following elements of Comet *a* 1894 are derived.

$$T = 1894 \text{ Feb. } 14.3968 \text{ Gr. M.T.}$$

$$\left.\begin{aligned} \omega &= 58^\circ\ 34'\ 50''.3 \\ \Omega &= 75\ \ \ 4\ \ 52\ .2 \\ i &= \ \ 6\ \ 31\ \ 57\ .3 \end{aligned}\right\} 1894.0$$

$$\log q = 0.088634$$

$$\begin{aligned} \text{C}-\text{O}: \quad \text{April } 6, \quad \Delta\lambda &= -34'', \quad \Delta\beta = +50''; \\ 9, \quad \Delta\lambda &= -15''. \quad \Delta\beta = +45'' \end{aligned}$$

Variation of the geocentric distance at the first observation shows that the normal parabola gives discrepancies of 2′ in longitude at these intermediate dates; while the discrepancies in latitude are increased, if an attempt is made to diminish the errors in longitude.

That the eccentricity differs sensibly from unity appears quite probable. Pending investigation of this point the subjoined Ephemeris may prove useful.

EPHEMERIS FOR GREENWICH MIDNIGHT.

1894	App. α	App. δ	log Δ	Br.
	h m s	° ′		
May 2	11 30 21	+14 35.7	9.9546	0.21
3	32 10	14 13.2	9.9615	
4	33 58	13 50.9	9.9684	
5	35 45	13 29.0	9.9752	
6	37 31	13 7.3	9.9820	0.18
7	39 15	12 45.9	9.9888	
8	40 59	12 24.8	9.9955	
9	42 41	12 4.0	0.0022	
10	44 23	11 43.4	0.0089	0.15
11	46 4	11 23.0	0.0155	
12	47 44	11 2.9	0.0221	
13	49 23	10 43.1	0.0286	
14	51 1	10 23.5	0.0352	0.13
15	52 38	10 4.1	0.0416	
16	54 15	9 44.9	0.0481	
17	55 51	9 26.0	0.0545	
18	57 26	9 7.3	0.0609	0.11
19	11 59 1	8 48.8	0.0672	
20	12 0 35	8 30.6	0.0735	
21	12 2 8	+8 12.5	0.0797	

OBSERVATIONS OF COMETS,

MADE AT THE OBSERVATORY OF THE CATHOLIC UNIVERSITY, WASHINGTON, D.C.,

BY REV. G. M. SEARLE.

1894 Greenwich M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
			Comet *b* 1893 (Brooks).					
	h m s		m s	′ ″	h m s	° ′ ″		
July 15 14 33 4	1	4	−1 31.8	−10 48	. . .	. . . .	9.750	0.702
17 14 23 48	2	5	−0 38.7	− 6 8	. . .	. . . .	9.732	0.676
19 14 21 0	3	5	−0 26.8	+ 6 41	. . .	. . . .	9.716	0.677
			Comet *c* 1893 (Brooks).					
Oct. 17 22 11 18	4	6	−0 22.3	− 6 2	12 23 1.39	13 34 39.5	*n*9.672	0.746
23 22 20 23	5	4	−0 35.0	− 5 5	12 31 2.45	17 35 29.1	*n*9.672	0.758
29 21 54 30	6	5	+1 17.1	+ 8 27	12 39 59.23	21 53 42.4	*n*9.688	0.726
21 54 30	7	2	−1 5.2	+ 6 10	. . .	. . . .		
21 54 30	8	4	+0 10.6	+ 0 49	. . .	. . . .		

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	10 33 59.77	. .	+36 3 3.2	. .	Yarnall 4533
2	10 57 17	. .	+31 43	. .	
3	11 15 29	. .	+28 2	. .	
4	12 23 22.80	+0.89	+13 40 50.0	− 8.5	W.B. XII, 355
5	12 31 36.43	+1.02	+17 40 44.7	−10.6	25 *Comae*, Yarnall
6	12 38 41.02	+1.11	+21 45 28.2	−12.8	W.B. XII, 768
7	12 41 3	. .	+21 47 45	. .	
8	12 39 48	. .	+21 53 6	. .	

COMET *b* 1894 (GALE),

From observations of this comet April 11, 12, 13, telegraphed from Capetown, Prof. KREUTZ computed elements, and telegraphed them from Kiel.

$$T = 1894\ \text{April}\ 13.82\ \text{Greenw. M.T.}$$

$$\left.\begin{aligned}\omega &= 324^\circ\ 18' \\ \Omega &= 206\quad 9 \\ i &= \ \ 87\quad 24\end{aligned}\right\}\ \text{M. Eq. 1894.0}$$

$$q = 0.9856$$

From these Father SEARLE computed the following ephemeris for Greenwich midnight, which was distributed by the *Science Observer*, on April 17.

	α	δ	Br.
	h m s	° ′	
1894 April 28.5	7 14 40	−27 35	5.5
May 2.5	8 5 28	−11 36	
6.5	8 47 32	+ 2 44	
10.5	9 21 0	+15 15	3.2

The brightness at discovery, Apr. 2, is taken as unity.

Mr. DOUGLAS of the Lowell Observatory at Flagstaff, Arizona, has telegraphed that he descried the comet April 26 15h Greenw. M.T. in $\alpha = 6^h\ 50^m$ and $\delta = -33^\circ\ 30'$. A second dispatch describes it as of the brightness of a 5^M star, having a round central nucleus of about 4′ diameter, and a narrow tail, 8′ long.

SUPPOSED COMET *c* 1894.

This object, announced by HOLMES of London, as discovered April 9, proves not to have been a comet; but the nebula N.G.C. 6503.

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ON THE DETERMINATION OF THE PRINCIPAL TERM OF THE NUTATION,

By KURT LAVES.

The differential equations for precession and nutation are

$$(1)\qquad \begin{cases} \dfrac{d\psi}{dt} = -\dfrac{1}{C.n}\,\dfrac{1}{\sin\omega}\,\dfrac{\delta V}{\delta\omega} \\[2ex] \dfrac{d\omega}{dt} = \dfrac{1}{C.n}\,\dfrac{1}{\sin\omega}\,\dfrac{\delta V}{\delta\psi} \end{cases}$$

where $$V = -\tfrac{3}{2}\,(C-A)\left\{\frac{M}{r^3}\sin^2\delta + \frac{m'}{r'^3}\sin^2\delta'\right\}$$

Here ω denotes the obliquity of the equator to a fixed ecliptic; ψ, the amount of retrograde motion of its node on this plane. C is the moment of inertia of the *Earth* about its axis of rotation; A, half the sum of the moments of inertia about the two principal axes lying in the plane of the equator; M and m' are the masses severally of the *Sun* and the *Moon*; r and r' the distances of their centers from the center of the *Earth*, δ and δ' their declinations.

The integration of these equations gives

$$(2)\qquad \begin{aligned} \psi &= \beta t + \beta_1 t^2 + \Psi \\ \omega &= \omega_0 + r_1 t^2 + \Omega \end{aligned}$$

The functions Ψ and Ω designate here the periodical terms, for which we have the expressions

$$(3)\qquad \begin{aligned} \Psi &= \lambda_1 \sin\text{☊} + \lambda_2 \sin 2\text{☊} + \lambda_3 \sin 2\text{☾} + \lambda_4 \sin 2\odot + \ldots \\ \Omega &= N \cos\text{☊} + r_2 \cos 2\text{☊} + r_3 \cos 2\text{☾} + r_4 \cos 2\odot + \ldots \end{aligned}$$

where ☊ represents the longitude of the ascending node of the *Moon's* orbit upon the ecliptic, ☾ and $\odot$ the longitudes of *Moon* and *Sun*.

The constants β, β_1, $\lambda_1 \ldots \lambda_4$, N, $r_2 \ldots r_4$ depend upon the elements of the orbits of the *Earth* and *Moon*, upon $\dfrac{C-A}{C}$ and the ratio of the mass of the *Moon* to that of the *Sun*.

Among all these coefficients, β and N deserve special attention, since they can be determined independently by direct observations. β is called the constant of lunisolar precession; N is the principal term of the nutation. The equations for β and N are

$$\beta = [3.687\,6097]\,\frac{C-A}{C} + [5.937\,5945]\left(\frac{1}{1+\frac{1}{\mu}}\right)\frac{C-A}{C} \qquad (4)$$

$$N = [5.365\,4318]\left(\frac{1}{1+\frac{1}{\mu}}\right)\frac{C-A}{C}$$

(See HILL'S paper, *On the Connection of Precession and Nutation with the Figure of the Earth*, (*Astr. Journ.*, no. 289, Vol. XIII.))

The numerical factors within brackets are common logarithms, $\mu = \dfrac{m'}{m}$ is the *Moon's* mass expressed in units of the *Earth's* mass. Since we can determine μ by the lunar equation or by tidal observations, the question arises whether it would not be preferable to use the equations (4) for finding N and $\dfrac{C-A}{C}$, because the determination of N by observation is not very satisfactory. Indeed, the probable error for β and N is about ±0″.015, but β is $= 50''.382$ and $N = 9''.223$; therefore β is known to $\frac{1}{3360}$ of its amount, but N only to $\frac{1}{615}$. In former times several applications of this method have been made. In the fifth book of the *Mécanique Céleste*, LAPLACE introduces the value of $\frac{1}{1+\frac{1}{\mu}}$, which he derived from the observations of the height of the tides at the harbor of Brest, into the equations for β and N, and derives a value of $N = 10''.06$. Later he reduced this value to 9″.65. ZACH started from the value of the mass of the *Moon* which resulted from DELAMBRE'S tables of the *Sun* and found $N = 9''.648$; DELAMBRE himself obtained $N = 9''.63$. BESSEL has applied the value of ZACH in his *Fundamenta Astronomiae* for the reduction of BRADLEY'S observations. In the tables of the *Sun* by HANSEN and OLUFSEN the value $N = 9''.271$ is applied, which results from HANSEN'S mass of the *Moon* and BESSEL'S value of β. Since I have no opportunity to examine the original papers, I have taken these facts from FOERSTER'S paper, *Über die bisherigen Annahmen in den Transformations-Elementen der astronomischen Ortsangaben*, (published in the *Berliner Astronomisches Jahrbuch* for 1870; Appendix, and reprinted in the author's "*Studien zur Astrometrie*." Berlin, 1888).

I am not aware of any other attempts, beside those mentioned above, to determine the constant of nutation in this way. The analytical expressions for β and N, determined by Poisson and Serret, were exact only to terms of the order of the squares of the eccentricities of the orbits of the *Moon* and *Earth* and the inclination of the *Moon's* orbit. We may also observe that the older determinations of the *Moon's* mass derived from the lunar equation, or from the observations of tides, were considerably inexact. Hence it was very natural to abandon this whole method for determining the nutation, and to rely only upon the results which were obtained from the observations of the fixed stars. But,—as Hill has recently developed β and N to the seventh power of small quantities, and thus rendered their analytical expressions very exact, and since the *Moon's* mass resulting from the lunar equation can now be determined with much greater precision than hitherto,—it seems worth while to draw attention again to this valuable method for determining the constant of nutation.

In no. 3156 of the *Astronomische Nachrichten*, I endeavored to show: 1) that the so-called lunar equation in the heliocentric motion of the *Earth* cannot be advantageously used for a determination of the mean solar parallax, but ought to be applied only in determining the mass of the *Moon*; 2) that by the resulting value of the mass of the *Moon* we get a determination of the nutation which can only be affected by a probable error of ±0″.012. Here it was assumed that the probable error of the solar parallax is ±0″.02, of the constant of the lunar equation ±0″.02, and of β ±0″.015 (See *Astronomische Nachrichten*, Vol. CXXXII, no. 3156, *Der Coefficient der sogenannten lunaren Gleichung der Erdbewegung und die Verwerthbarkeit derselben für die Kenntniss des Hauptgliedes der Nutation*).

Since some difficulties have recently arisen in connection with the lunar equation, it seems desirable briefly to recapitulate the principal points to be considered.

The inequality in question is that arising from the motion of the center of the *Earth*, T, around the common center of gravity, S, of the *Earth* and *Moon*. Since S describes the annual orbit around the *Sun*, we must compute for any given instant the coordinates of the center of the *Earth*, T, with respect to S, when we wish to pass from the heliocentric coordinates of S to the heliocentric coordinates of T. Putting r, b, λ for the heliocentric polar coordinates of T, we shall have to determine the perturbations δr, δb, $\delta\lambda$ which are due to the presence of the *Moon*. Of special interest for us is $\delta\lambda$ for which we have the expression

$$\delta\lambda = \frac{\mu}{1+\mu}\,\frac{r'}{r}\,\frac{\cos b' \sin(☾ - \odot)}{\sin 1''} \tag{5}$$

where r', b', ☾ represent the geocentric coordinates of the *Moon*. The right-hand member may be regarded as the product of a constant factor, P, and a variable factor which is a function of the time. In order to determine this factor P, LeVerrier discussed the following long series of observations of the *Sun*:

Greenwich,	1816 – 1826
	1827 – 1850
Paris,	1804 – 1814
	1815 – 1845
Koenigsberg,	1814 – 1830

He found $P = 6''.50 \pm 0''.03$.

Recently the question has arisen, in what manner LeVerrier computed the lunar equation in his discussions of the observations of the *Sun*, and how the quantity P was defined by him. In no. 3155 of the *Astronomische Nachrichten*, Newcomb stated the two ways in which LeVerrier could have computed the lunar equation for each observation. He says: "There are two methods of proceeding to determine the motion in question. We may, in effect, compute the approximate position of the *Moon*, including equation of the center, evection and variation, and thus determine the corresponding coordinates of the *Earth* relative to the common center of gravity. These coordinates, referred to the *Sun* as variations of the heliocentric position of the *Earth*, will then give the inequality sought. This is substantially what LeVerrier has done in his tables of the *Sun*. But the separate computation of the inequality in this way for each observation is extremely laborious. It is therefore desirable to develop the inequality in question so as to present it in tables whose arguments increase uniformly with the time. But when we do this we find that the mean orbit of the *Moon*, as viewed from the *Sun*, is not a circle, but that it is systematically flattened in the direction of the syzigies, and elongated in the direction of the quadratures. This is, in fact, the effect of the Variation. It follows, therefore, that if we should consider that as applicable to the determination of the inequality, the latter would be systematically too small in longitude, and too large in radius vector." Since with each of these methods the constant will be different, it is an important question whether LeVerrier's value of $P = 6''.50$ should be considered as the value of the coefficient corresponding to the first, or to the second method. On account of the great labor which the former method entailed, Newcomb supposed that LeVerrier probably would have used the second method. Concerning this supposition, E. J. Stone has called attention to the fact, that in an example which LeVerrier gives, he used the true longitudes, and not the mean longitudes; accordingly, we see that LeVerrier followed here the first, and not the second method; and "it would therefore be scarcely probable," continues Stone, "that LeVerrier should have taken all the necessary precautions in working out an example, and yet should have neglected the precautions necessary to obtain an accurate value of the angle from a discussion of such an extended series of observations" (See *Monthly Notices*. Vol. LIII, no. 6, April, 1893). In my *Inaugural Dissertation* I was led to exactly the same result. (See *Beiträge zur Bestimmung und Verwerthung der Bewegung der Erde um den Schwerpunkt des Systems Erde-Mond*, 1891, *Universität zu Berlin*). Although Stone's argument seemed very conclusive, I believed that a final decision of the question could only be given by a careful examination of LeVerrier's manuscripts in Paris. At my request, M. Gaillot of the Paris Observatory has critically examined the original manuscripts, and has just published his very interesting results in the *Bulletin Astronomique*, Tome XI, Février, 1894 (*Sur la détermination du coefficient de l'équation lunaire effectuée par* LeVerrier). He confirmed Stone's opinion and my own, that LeVerrier had calculated rigorously the lunar equation at intervals of two days. Besides that, M. Gaillot points out the important fact that LeVerrier's constant must be increased by $+0''.03$, owing to a small systematic error, affecting the Solar Tables of Delambre used in the calculations. M. Gaillot has kindly communicated to me, in a letter dated Jan. 10, 1894, the result of his examination of LeVerrier's definition of the constant P. He writes: "*Le coefficient de l'équation lunaire est bien définie par* LeVerrier *tel que vous l'avez compris,* $\frac{\mu}{1+\mu}\;\frac{a}{a'\sin 1''}$."

Starting from the lunar equation,

$$\pi = 0.016577\,.\,P\left(1+\frac{1}{\mu}\right)$$

and assuming $\pi = 8''.80, \quad P = 6''.53.$

we find $\quad 1+\frac{1}{\mu} = 81.29.$

Dividing the equation for β by that for N, in (4), we obtain $\frac{\beta}{N} = [8.3221779]\left(1+\frac{1}{\mu}\right)+[0.5721627]$; introducing the value for $\left(1+\frac{1}{\mu}\right)$, and the value $50''.382$ for β, we find $N = 9''.260$.

The relation of N to the quantities P, π, β, c (eccentricity of the *Moon's* orbit) is given by the equation (see *Astron. Nachr.* no. 3156).

$$dN = 0.45\,dP - 0.34\,d\pi + 0.17\,d\beta + 0.002\,de.$$

We see that a variation in the values of P and π affects the value of N the most. With the assumed probable errors.

$$\Delta P = \pm 0''.02 \quad \Delta\pi = \pm 0''.02 \quad \Delta\beta = \pm 0''.015 \quad \Delta e = \pm 1''.0.$$

we obtain $\quad \Delta N = \pm 0''.012.$

An accurate determination of P and π is therefore of fundamental importance for the constant of nutation also. It is a curious fact, that all the determinations of N obtained by this method give results considerably larger than those which are derived directly from observations of the stars.

Hitherto P has been determined only from the meridian observations of the *Sun*; LeVerrier found, from such observations extending over 58 years, $P = 6''.53 \pm 0''.03$ (corrected value); Newcomb, from observations extending over 18 years, $P = 6''.55 \pm 0''.06$; Deichmüller, from observations extending over 7 years, $P = 6''.75 \pm 0''.11$. It seems scarcely possible that the accuracy obtained by LeVerrier from so long a series of observations will be surpassed by further accumulations of observations of the *Sun*, since some systematic errors, which in these observations cannot be avoided, vitiate the results deduced from them. But by the heliometric observations of such planets as come nearer to the *Earth* than the *Sun*, we have a method, which, by its accuracy as well as by the possibility of measuring larger angles than is possible in the case of the *Sun*, seems likely to become of the greatest importance for measurements of extreme precision. Since *Mars* can come as near to the *Earth* as about 0.4 of the planetary unit, half of the major axis of the ellipse which T describes around S would be observed under an angle of about $16''$. I have discussed the excellent heliometer observations of *Mars*, which Dr. Gill has made in 1877 at Ascension Island, and from which he has deduced a very accurate value of π, and I have derived $P = 6''.53 \pm 0''.05$. It is a very striking fact, that here the probable error is relatively so very small, although the observations extend only over two months. This fact on the one hand establishes the high accuracy of the heliometric observations of Dr. Gill, and shows on the other the superiority of this method of deriving P as compared with the method depending upon observations of the *Sun* (See *Memoirs of the Royal Astronomical Society*, Vol. XLVI, 1880–81; compare also Newcomb's paper in no. 311 of the *Astronomical Journal*: "Considerations on the Best Method of Determining Positions of the Planets by Observation," 1894).

And now it is evident that the great mass of material which the large number of small planets afford ought to be utilized in a systematic manner. The orbits of such planets which come nearer to the *Earth* than the unit of planetary distance ought to be carefully examined and ephemerides of all possible accuracy computed for their oppositions. Since the number of such planets which are advantageously situated is not large, the amount of labor spent in this direction need not be so very great. Professor Tietjen's intention to discontinue the careful computation of the orbits of such planets as do not belong to the class above mentioned, is fully justified; and the office of the *Berliner Jahrbuch* will doubtless now begin the careful investigation of the orbits of these more interesting planets. The photographic observations of such planets as are not to be more critically investigated will afford sufficient material for keeping track of them. Great help will certainly be secured for the investigation of such interesting orbits by the application of the method of Gyldén and by the construction of tables for the small planets, founded upon this method.

In order to observe such planets during their opposition, by GILL's heliometric method, a sufficient number of stars near the apparent path of the planet in opposition ought to be selected as comparison-stars. By meridian observations the positions of these stars are to be determined; as far as possible the relative positions are to be measured by the heliometer, in order to correct the results of the meridian observations. In this manner a homogeneous system of fundamental stars will be obtained. The photographic chart of the heavens, when completed, will be of considerable importance for this work. If many heliometric observations of favorable planets are thus secured by different observers, we shall certainly be able to obtain material which will give the value of P and π with a probable error not exceeding $\pm 0''.01$. The probable error of the constant of nutation would thus be reduced to $\pm 0''.006$, a degree of accuracy which could probably not be obtained by the method of determining N from meridian observations of stars near the pole.

The University of Chicago, 1894 *April.*

ELEMENTS AND EPHEMERIS OF PLANET (*175*) *ANDROMACHE*,

[Letter from Mr. BERBERICH to the Editor.]

As I have already written you, I computed the perturbations produced by *Jupiter* and *Saturn*, from 1893 August back to 1877 October, using the method of variation of the elements. The interval was 40 days for *Jupiter*, 1893 to 1882, and 80 days for 1882 to 1877, as likewise for *Saturn* for the whole period of 16 years.

Following are the uncorrected elements for the three observed apparitions:

	T = 1877 Oct. 11.0	1892 March 6.0	1893 Aug. 8.0
	° ′ ″	° ′ ″	° ′ ″
M =	30 54 33.4	210 23 44.9	299 4 11.0
ω =	298 33 36.2	299 44 19.9	299 49 1.8
Ω =	25 36 3.8	25 27 18.6	25 27 14.8
i =	3 11 42.8	3 10 54.0	3 10 51.4
φ =	12 12 12.2	11 41 8.2	11 39 45.8
μ =	618″.51716	614″.8089	614″.94300
$\log a$ =	0.505770	0.507511	0.507448

The epochs are expressed in mean time Berlin; the position of the orbit refers to the mean equinox 1890.0.

The effect of the great perturbation by *Jupiter* will best be seen by comparing the elements corresponding to the same relative positions of the two bodies. Thus we have for the epochs when the difference of heliocentric longitude ♃ — (175) was 180°, the following values of μ and φ;

	μ	φ
1881 November,	$\mu = 617''.422$	$\varphi = 12°\ 9'\ 28''$
1893 February,	$= 614\ .859$	$= 11\ 40\ 13$

and for the difference = 110°

	μ	φ
1883 March.	$\mu = 617''.838$	$\varphi = 12°\ 7'\ 42''$
1894 August,	$= 615\ .334$	$= 11\ 38\ 30$

The time of conjunction of *Jupiter* and *Andromache* was 1887 May 17; the result of the perturbation is a decrease of the mean motion by about $2''.5$, and of the angle of eccentricity by 29′. Comparing the observations with the elements given above, I found the following deviations (O — C):

	δG	δg
1877 October 16.5970	$\delta G = +8593''.8$	$\delta g = +7''.5$
1892 March 4.5000	+ 81.5	+9.6
1893 May 19.3919	— 0.1	—0.3
August 1.3961	— 0.1	+0.1

Here G is the longitude, and g the latitude with respect to the plane of the orbit. The high amount of the first δg is almost wholly produced by the perturbations, as the comparison with the elements of 1893 gives only $\delta g = +492''$. It seemed necessary to apply some corrections to the orbit before computing the ephemeris for the next opposition which will nearly coincide with the perihelion-time of *Andromache*, where any error of the planet's place will appear increased in consequence of the relatively small distance from the earth.

From the four places already mentioned, I found

T = 1893 Aug. 8.0

$$\delta M_0 = +0'\ 4''.6 \qquad \delta i = +0'\ 8''.6$$
$$\delta\omega = -5\ 27.0 \qquad \delta\varphi = -1\ 37.6$$
$$\delta\Omega = +0\ 56.0 \qquad \delta\mu = -0''.72588$$

The residuals between observation and computation are now reduced to

	δG	δg
1877 Oct. 16	$\delta G = +35''.7$	$\delta g = +4''.8$
1892 Mar. 4	= — 0.3	= 0.0
1893 May 19	= + 1.0	= 0.0
Aug. 1	= — 0.4	= —1.0

A more exact refinement of the orbit of (175) *Andromache* will only be possible after including the observations of the present opposition. Taking into account the perturbations by the two great planets, we obtain the following elements, upon which the ephemeris depends.

$$T = 1894 \text{ Aug. } 23.0 \text{ Berlin M.T.}$$
$$M = 3°\ 52'\ 54''.5$$
$$\left.\begin{aligned} \omega &= 299\ 46\ \ 4\ .9 \\ \Omega &= 25\ 27\ 32\ .5 \\ i &= 3\ 10\ 59\ .4 \end{aligned}\right\} \text{M. Equ. 1890.0}$$
$$\varphi = 11\ 36\ 51\ .4$$
$$\mu = 614''.63354$$
$$\log a = 0.507593$$

The planet is now approaching *Jupiter* again, and will be in conjunction with it in 1898. The great perturbation will then repeat itself, although to a smaller amount. But as the position of the conjunction is shifting by only 12° every 11 years, there will still follow several perturbations retarding the planet's motion. The final effect must be a very large one, and *Andromache* will remain behind its undisturbed place, perhaps for a whole century. This planet therefore deserves peculiar attention, for it will furnish an excellent means for determining an accurate value of the mass of the planet *Jupiter*.

Ephemeris for Berlin Midnight.

1894	A.R. app.	Decl. app.	log Δ	log r
	h m s	° '		
July 14	22 41 34	−12 50.7	0.2431	0.4105
16	41 22	12 53.4		
18	41 4	12 56.5		
20	40 40	13 0.1		
22	40 10	13 4.2	0.2269	0.4103
24	39 34	13 8.7		
26	38 53	13 13.7		
28	38 6	13 19.0		
30	37 14	13 24.7	0.2132	0.4102
Aug. 1	36 17	13 30.7		
3	35 14	13 37.1		
5	34 7	13 43.7		
7	32 56	13 50.5	0.2029	0.4103
9	31 41	13 57.4		
11	30 22	14 4.5		
13	22 29 0	−14 11.7		
Aug. 15	22 27 35	−14 18.9	0.1966	0.4104
17	26 8	14 26.1		
19	24 39	14 33.3		
21	23 8	14 40.4		
23	21 37	14 47.3	0.1946	0.4107
25	20 5	14 54.0		
27	18 33	15 0.5		
29	17 1	15 6.7		
31	15 30	15 12.7	0.1974	
Sept. 2	14 1	15 18.3		
4	12 34	15 23.4		
6	11 9	15 28.2		
8	9 47	15 32.5	0.2046	
10	8 29	15 36.3		
12	7 14	15 39.7		
14	6 4	15 42.6		
16	4 57	15 44.9	0.2159	
18	3 56	15 46.7		
20	2 59	15 48.0		
22	2 8	15 48.7		
24	1 22	15 48.8	0.2306	
26	0 42	15 48.4		
28	22 0 7	15 47.5		
30	21 59 38	15 46.0		
Oct. 2	21 59 16	−15 44.0	0.2480	

A variation of ±1ᵐ in A.R. produces one of ±6′ in Decl. Brightness of *Andromache* at opposition = 10ᴹ.

OBSERVATIONS OF COMET *b* 1894 (*GALE*),

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

1894 Cincinnati M.T.	*	No. Comp.	☄ — *		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	' "	h m s	° ' "		
April 28 8 2 24	1	9 , 9	+0 24.04	+5 48.1	7 17 0.84	−26 40 14.4	9.583	0.846
29 8 23 23	2	10 , 8	−0 18.72	−5 36.6	7 30 48.26	−22 42 3.9	9.587	0.832
30 8 16 56	3	10 , 4	−1 14.57	+5 9.7	7 13 48.27	−18 39 18.9	9.550	0.830
30 8 16 56	4	10 , 4	−1 16.66	+0 44.9	7 43 48.35	−18 39 19.6	9.550	0.830
May 2 8 58 22	5	10 , 8	+1 3.28	−2 56.6	8 8 39.84	−10 16 19.7	9.573	0.792
4 8 58 6	6	8 . 8	+1 41.65	+2 19.5	8 30 48.92	− 2 18 59.8	9.544	0.758
7 9 12 44	7	12 , 12	+0 32.99	−5 1.4	8 59 52.05	+ 8 9 46.0	9.541	0.687

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ' "	"	
1	7 16 36.83	−0.03	−26 45 55.7	−6.8	Gould. G.C. 9374
2	7 31 6.89	+0.09	−22 36 21.0	−6.3	Weiss-Argel. 5755
3	7 45 2.65	+0.19	−18 44 22.8	−5.8	Eq. comparison with Weiss-Argel. 6051
4	7 45 4.82	+0.19	−18 39 58.7	−5.8	Eq. comparison with last
5	8 7 36.18	+0.38	−10 13 18.9	−4.2	W. Bessel VIII. 120
6	8 29 6.71	+0.56	− 2 21 16.7	−2.6	Paris 10528 and eq. comp. with Paris 10532 [and Karlsruhe
7	8 59 18.23	+0.83	+ 8 14 47.6	−0.2	W. Bessel VIII. 1458

MICROMETER OBSERVATIONS OF COMET *b* 1894 (*GALE*),

MADE AT THE CATHOLIC UNIVERSITY, WASHINGTON, D.C.,

BY REV. GEORGE M. SEARLE.

1894 Greenwich M.T.	*	No. Comp.	☄ — *		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
April 30 14 8 41	1	3	+2 41.76	+2 4.1	7 43 56.52	−18 36 47.7	9.615	0.806
14 8 41	2	3	−1 8.74	+3 22.1	. . .	. . .	9.615	0.806
May 1 13 47 0	3	5	−0 27.28	−4 23.7	7 56 18.01	−14 32 31.9	9.565	0.810
13 47 0	4	5	−0 53.40	+2 58.4	7 56 18.01	−14 32 30.7	9.565	0.810
14 4 59	5	2	+3 13.02	−7 59.2	7 56 26.51	−14 29 37.2	9.590	0.802

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	7 41 14.58	+0.18	−18 38 46.1	−5.7	Weiss-Argelander 5984
2	7 45 5	+0.19	−18 40 4	−5.8	Comparison with Star 1
3	7 56 45.00	+0.29	−14 28 3.1	−5.1	Weisse-Bessel VII, 1619
4	7 57 11.12	+0.29	−14 35 23.9	−5.2	" " VII, 1636
5	7 53 13.22	+0.27	−14 21 33.1	−4.9	" " VII, 1526

OBSERVATIONS OF COMETS,

MADE AT THE DUDLEY OBSERVATORY,

BY LEWIS BOSS.

1894 Albany M.T.	*	No. Comp.	☄ — *		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
			Comet *b* 1894 (Gale).					
h m s			m s	′ ″	h m s	° ′ ″		
May 1 9 15 37	1	16 , 8	−0 15.34	−0 26.8	7 56 29.54	−14 28 34.0	9.588	0.819
2 8 31 13	2	16 , 8	+0 43.93	+2 49.2	. . .	. . .	9.507	0.825
3 8 56 49	3	18 , 6	+2 3.98	+0 41.3	8 19 41.29	− 6 20 41.7	9.532	0.739
			Comet *a* 1894 (Denning).					
Apr. 27 10 51 7	8	10 , 5	+2 18.69	+0 56.6	11 21 14.76	+16 28 50.3	9.336	0.612
29 10 35 20	9	18 , 9	+1 24.94	−2 15.5	11 25 6.67	+15 41 20.6	9.290	0.618
May 2 11 14 44	10	9	−0 42.20	−4 35.0	11 30 47.23	+14 31 21.7	9.377	0.642
8 10 58 56	11	6 , 4	−4 23.93	−3 54.5	11 41 37.30	+12 19 39.0	9.420	0.673
9 10 47 19	12	18 , 6	−0 26.80	−4 18.1	11 43 19.95	+11 58 33.7	9.394	0.673

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	7 56 44.59	+0.29	−14 28 2.1	−5.1	Paris 9850
2	8 7 20	+0.38	−10 31	−4.3	S.DM. −10°2422
3	8 17 36.84	+0.47	− 6 21 19.6	−3.4	Paris 10268
8	11 18 54.24	+1.83	+16 27 59.0	−5.3	Paris 13931
9	11 23 39.92	+1.81	+15 43 41.6	−5.5	W.B. XI, 398
10	11 31 27.64	+1.79	+14 36 2.6	−5.9	Paris 14181
11	11 45 59.45	+1.78	+12 23 40.4	−6.9	Paris 14468
12	11 43 44.98	+1.77	+12 2 58.6	−6.8	DM. 12°2372 comp. with Paris 14347

May 8. The comet was barely visible at intervals, even in unilluminated field. There was a light fog, which contributed materially to lessen the brightness of the image. This observation is probably entitled to one-third the weight due to preceding observations of this series.

May 9. DM. 12°2372 —Paris 14347 = $+4^{m}\,22^{s}.71$; +4′ 13″.5. Notwithstanding the moonlight, the comet was well seen with illuminated wires.

ELLIPTIC ELEMENTS OF COMET *a* 1894, (*DENNING*),

BY LEWIS BOSS.

This comet appears to belong to those associated with *Jupiter*. I have found the following elements.

Epoch: 1894 April 27.5 Greenw. M.T.

$$\begin{aligned} M &= 9^\circ\ 31'\ 45''.28 \\ \left.\begin{aligned} \omega &= 46\ \ 56\ \ 20\ .2 \\ \Omega &= 83\ \ 52\ \ 10\ .4 \\ i &= \ \ 5\ \ 34\ \ 33\ .3 \end{aligned}\right\} & 1894.0 \\ \varphi &= 45\ \ 18\ \ 19\ .6 \\ \mu &= 446''.8386 \\ \log a &= 0.5999040;\ \text{Period } 7^y.94 \end{aligned}$$

The three normal places, March 27.5, April 9.5 and April 27.5, are exactly represented, except for a discrepancy of 0″.2 between the computed and observed latitudes for April 9.5. Following is the result of a cursory comparison (only approximate) with the individual observations employed. The residuals are in the sense observed—computed.

Gr. M.T.		$\Delta\alpha$	$\Delta\delta$	
	h	s	″	
March 27	8	+0.28	+0.9	Strassburg
27	9	+0.18	−1.8	Pulkowa
27	10	+0.13	−1.6	Hamburg
27	14	−0.33	+0.4	Albany
27	16	+0.02	−1.7	Princeton
April 5	13	[−1.09]	−0.9	Copenhagen
5	15	−0.04	+0.5	Northfield
5	17	0.00	+3.0	Princeton*
April 6	16	−0.25	−2.9	Albany
7	9	+0.41	+2.1	Lyons
8	12	[−1.06]	−3.2	Copenhagen
9	10	[−0.90]	+1.2	Copenhagen
9	14	+0.29	+2.2	Albany
12	20	+0.09	−1.0	Cincinnati
April 25	17	−0.08	−2.5	Albany
26	15	+0.22	+6.2	Albany
27	16	−0.18	−4.5	Albany
29	15	+0.03	+0.8	Albany

---

* Corrected

Also the following which were more carefully compared for a test of the elements.

Gr. M.T.		$\Delta\alpha$	$\Delta\delta$	
	h	s	″	
May 8	16	+1.87	+8.9	Albany
9	16	+0.62	−1.3	Albany

The observation of May 8 was made with extreme difficulty, as will be seen by reference to the published report.

The comet may make a close approach to *Jupiter* near longitude 330°, and a much closer one (say within 0.2) at longitude 270°±. In 1890, *Jupiter* was in conjunction with the comet then at its aphelion, but the distance appears to have been always greater than 1.0.

EPHEMERIS FOR GREENWICH MIDNIGHT.

1894	App. α	App. δ	log Δ
	h m s	° ′ ″	
May 20	12 1 29.76	+8 24 38.7	9.9997
21	3 6.68	8 6 10.5	0.0060
22	4 43.10	7 47 53.9	0.0124
23	6 19.05	7 29 48.7	0.0187
24	7 54.54	7 11 54.6	0.0249
25	9 29.61	6 54 11.4	0.0311
26	11 4.27	6 36 38.8	0.0373
27	12 38.55	6 19 16.7	0.0434
28	14 12.47	6 2 4.7	0.0496
29	15 46.06	5 45 2.6	0.0556
30	17 19.34	5 28 10.2	0.0616
31	18 52.31	5 11 27.3	0.0676
June 1	20 25.00	4 54 53.6	0.0735
2	21 57.44	4 38 28.9	0.0794
3	23 29.63	4 22 13.0	0.0853
4	25 1.58	4 6 5.8	0.0911
5	26 33.30	3 50 7.2	0.0968
6	28 4.82	3 34 16.9	0.1026
7	29 36.14	3 18 34.8	0.1083
8	31 7.26	3 3 1.0	0.1139
9	12 32 38.16	+2 47 35.3	0.1195

Brightness May 20 is 0.096; June 9, 0.046.

HELIOCENTRIC COORDINATES FOR THE EQUATOR.

$$\begin{aligned} x &= r[9.9979639]\sin(v+220^\circ\ 46'\ 46''.5) \\ y &= r[9.9609635]\sin(v+133\ \ 14\ \ 54.0) \\ z &= r[9.6201139]\sin(v+118\ \ 33\ \ 53.8) \end{aligned}$$

ELEMENTS AND EPHEMERIS OF COMET *b* 1894 (*GALE*),

BY REV G. M. SEARLE.

I have computed the following elements of Comet *b* 1894 from the observations at the Cape of Good Hope, April 11 and 13, with mine made at Washington on May 1.

$$\begin{aligned} T &= \text{April } 13.618 \text{ Gr. M.T.} \\ \left.\begin{aligned} \Omega &= 206^\circ\ 39'.6 \\ \omega &= 324\ \ 32\ .6 \\ i &= \ \ 86\ \ 39\ .6 \end{aligned}\right\} & 1894.0 \\ q &= 0.9827 \end{aligned}$$

From these we have the following ephemeris:

Gr. M.T.	α	δ	log Δ	Brightness
	h m	° ′		
May 10.5	9 23.8	+16 28	9.639	1.71
12.5	38.8	20 55		
14.5	9 51.7	24 35	.714	
16.5	10 3.0	27 35		
18.5	13.3	30 5	9.786	0.77
20.5	10 22.8	+32 9		
May 22.5	10 31.1	+33 53	9.851	
24.5	10 59.3	35 21		
26.5	11 26.5	+36 36	9.908	0.49

Owing to the unfavorable intervals, and merely approximate character of the computation, the ephemeris cannot be very accurate, but as the comet is quite bright, it can probably be easily found.

REDISCOVERY OF PERIODIC COMET OF TEMPEL (1873 II = 1878 III).

The second periodic comet of TEMPEL was discovered by FINLAY, at Capetown,

1894 May 8.6228 Gr. M.T. $\alpha = 23^h 45^m 21^s.1$, $\delta = -4° 51' 11''$,

quite near to the place assigned by SCHULHOF's ephemeris in *Astr. Nachr.* 3218. It is described as circular; of 1′ diameter; 11^M, or fainter; some central condensation; no tail.

The corrections for SCHULHOF's ephemeris appear to be $\Delta\alpha = +0^m 55^s.0$, $\Delta\delta = +2' 31''$. Applying these we have, for Washington time.

1894	α	δ	log Δ
	h m s	° ′	
May 13.5	0 1 32	−3 51.8	0.2234
15.5	0 7 49	−3 28.8	0.2226
17.5	0 14 3	−3 6.1	0.2248

NOTATION OF ASTEROIDS.

Numbers for newly discovered small planets have been assigned as follows, by the Berlin *Rechen-Institut.*

AQ	1894 Jan. 8	CHARLOIS	(379)
AR	Jan. 8	"	(380)
AS	Jan. 10	"	(381)
AT	1894 Jan. 29	CHARLOIS	(382)
AU	Jan. 29	"	(383)

AW has been omitted in the numeration as having been observed only Jan. 30 and Feb. 3. It may be rediscovered next year, as it will be near its descending node when in opposition (April 1895).

BA is probably identical with 1892 *S*, which was lost soon after discovery.

NOTICE.

Prof. BAKHUYZEN asks to correct the Notice in *A. J.*, no. 315, requesting observations of 6794 *R Lyrae* for Mr. PANNEKOEK, by substituting the years 1890–92, for 1880–82.

CORRIGENDA.

No. 316, p. 32, line 6, *for* Comet *b* 1893 (BROOKS), *put* Comet 1893 II.
p. 32, line 16. " 1894.0, " 1893.0.

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ON THE PARALLAX AND PROPER MOTION OF β *PERSEI.*

By F. L. CHASE.

According to the theory of Dr. CHANDLER, given in *A. J.*, no. 255, viz.: that the irregularities in the periodic fluctuations in brilliancy of β *Persei*, are due to the existence of a third body around which, as a primary, *Algol* and its smaller dark companion revolve in a period of about 130 years, this variable should have a parallax of about 0″.07. If the parallax were no smaller than this amount, it seemed quite possible that it might be detected by means of the Yale heliometer. Accordingly I have made a series of observations extending over a period of a year and a half with this object in view.

Two fairly well situated stars, which I shall designate by *a* and *d*, their magnitudes being 7.3 and 7.8 respectively, and their position-angles from *Algol* (β), 286° and 69° roughly, were selected for comparison-stars. In order to serve as a basis for future investigation as to any change in the place of *Algol*, observations were made also with reference to two other comparison-stars (*b* and *c*) situated in a direction from β nearly at right-angles to the former pair, their position-angles from β being roughly 191° and 359°. For a time both distances and position-angles were observed, but later the plan was altered to the extent of dropping the latter, since they are so far less accurate.

Except on one occasion, the first pair of distances upon which the parallax chiefly depends, were observed twice each night, either in the order, β*a*, β*d*, β*d*, β*a*, or β*d*, β*a*, β*a*, β*d*, so that the mean value for each distance may be regarded as observed at the same time.

The distances β*b*, β*c*, on the other hand being considered of less importance, were observed but once each night. Every precaution was taken to eliminate, as far as possible, any systematic errors, by reversing the prism eye-piece, scales, position-circle, and changing the order of observation on different nights.

Following are the resulting measured distances, corrected for refraction and aberration, to which are added the thermometer-reading and character of seeing: 1 signifying perfect, and 4, conditions too unfavorable for observation:

OBSERVED DISTANCES.

Date	β*a*	β*d*	β*b*	β*c*	Temp. F.	Images	Steadiness
1892	R	R	R	R	°		
Mar. 4	159.6300	185.1190	218.460	178.786	31	2–3	2
5	.6405	.1275	. . .	. . .	32	2	1–2
6	.6370	.1285	.507	.799	34	2–3	2–3
7	.6530	.1470	.509	.793	40	2	2
9	.6420	.1430	.461	.806	39	2–3	3
13	.6475	.1415	.474	.788	25	3	2
14	.6450	.1405	.491	.761	21	2	2
15	.6445	.1315	. . .	. . .	24	2–3	2–3
July 18	.6735	.1530	.508	.810	59	1–2	1–2
20	.6530	.1355	.518	.793	58	2	3
21	.6695	.1230	.501	.808	61	2	2–3
23	.6650	.1460	.518	.792	66	1–2	2–3
25	.6475	.1250	.487	.810	71	2	2–3
26	159.6510	185.1430	218.548	178.760	74	3	3

Date	βa	βd	βb	βc	Temp. F.	Images	Steadiness
1893	R	R	R	R	°		
Feb. 8	159.6405	185.1240	218.506	178.789	14	2	3
14	.6560	.1535	.531	.831	30	3	3
20	.6470	.1250	.469	.819	55	. .	. .
24	.6495	.1295	.484	.775	20	1	1–2
26	.6365	.1355	.517	.810	24	2	2–3
Mar. 1	.6415	.1355	.511	.796	28	1–2	2–3
Aug. 7	.6565	.1510	.532	.782	62	3	3
8	.6620	.1440	.519	.811	67	1–2	1–2
9	.6725	.1285	.510	.838	65	2	2
10	.6825	.1590	.525	.798	63	3	2–3
11	.6500	.1505	.493	.802	66	1–2	2–3
15	159.6195	185.1550	218.519	178.792	64	2–3	3

The treatment of these observations has been carried out in the same way as for those of β *Cygni* in *A. J.*, no. 307. The following table gives the mean sums and differences for each night, and the differences corrected so as to reduce them all to the same normal scale-value.

Sums, Differences and Corrected Differences.

Date	$\beta a+\beta d$	$\beta d-\beta a$	Corr. Diff.	$\beta b+\beta c$	$\beta b-\beta c$	Corr. Diff.
1892	R	R	R	R	R	R
Mar. 4	344.749	25.489	25.492	397.246	39.674	39.679
5	.768	.487	.489	. . .	. . .	. . .
6	.765	.491	.493	.306	.708	.708
7	.800	.494	.493	.302	.716	.716
9	.785	.501	.501	.267	.655	.658
13	.789	.494	.494	.262	.686	.690
14	.785	.495	.495	.252	.730	.735
15	.776	.487	.488	. . .	. . .	. . .
July 18	.826	.480	.477	.318	.698	.696
20	.789	.482	.482	.311	.725	.724
21	.792	.454	.454	.309	.693	.692
23	.811	.481	.479	.310	.726	.725
25	.772	.478	.479	.297	.677	.677
26	.794	.492	.492	.308	.788	.787
1893 Feb. 8	.764	.484	.486	.295	.717	.718
14	.809	.497	.496	.362	.700	.694
20	.772	.478	.479	.288	.650	.651
24	.779	.480	.481	.259	.709	.713
26	.772	.499	.500	.327	.707	.705
Mar. 1	.777	.494	.495	.307	.715	.715
Aug. 7	.807	.495	.494	.314	.750	.749
8	.806	.482	.481	.330	.708	.705
9	.801	.456	.455	.348	.672	.668
10	.841	.477	.473	.323	.727	.725
11	.800	.500	.499	.295	.691	.692
15	.774	.536	.537	.311	.727	.726
Mean	344.789		25.4878	397.302		39.706

The parallax factors for β *Persei*, relative to the different comparison-stars, are as follows:

For β relative to a	$0.992\,\mathrm{R}\cos(\odot-123^\circ\,52')$
" " " d	$0.895\,\mathrm{R}\cos(\odot-337\;\;25\;)$
" " " b	$0.829\,\mathrm{R}\cos(\odot-224\;\;51\;)$
" " " c	$0.860\,\mathrm{R}\cos(\odot-\;58\;\;18\;)$

If x be the required correction to the assumed difference $\beta d-\beta a$, y the variation of this difference due to the annual proper motions, x' and y' these same quantities with reference to $\beta b-\beta c$, and π the parallax of β relative to the comparison-stars, there result the following equations of condition:

EQUATIONS OF CONDITION.

$$\begin{array}{llllll} & & & & & \text{Wt.} \\ 1.00x & -0.73y & +1.63\pi & = & +0^{\mathrm{R}}.0042 & \frac{1}{2} \\ 1 & -0.73 & +1.62 & = & +0.0012 & 1 \\ 1 & -0.72 & +1.60 & = & +0.0052 & 1 \\ 1 & -0.72 & +1.59 & = & +0.0052 & 1 \\ 1 & -0.72 & +1.56 & = & +0.0132 & 1 \\ 1 & -0.71 & +1.49 & = & +0.0062 & 1 \\ 1 & -0.70 & +1.47 & = & +0.0072 & 1 \\ 1 & -0.70 & +1.45 & = & +0.0002 & 1 \\ 1 & -0.46 & -1.69 & = & -0.0108 & 1 \\ 1 & -0.45 & -1.71 & = & -0.0058 & 1 \\ 1 & -0.45 & -1.72 & = & -0.0338 & 1 \\ 1 & -0.44 & -1.74 & = & -0.0088 & 1 \\ 1 & -0.44 & -1.77 & = & -0.0088 & 1 \\ 1 & -0.44 & -1.77 & = & +0.0042 & 1 \\ 1 & +0.10 & +1.80 & = & -0.0018 & 1 \\ 1 & +0.12 & +1.77 & = & +0.0082 & 1 \\ 1 & +0.14 & +1.74 & = & -0.0088 & 1 \\ 1 & +0.15 & +1.71 & = & -0.0068 & 1 \\ 1 & +0.15 & +1.69 & = & +0.0122 & 1 \\ 1 & +0.16 & +1.66 & = & +0.0072 & 1 \\ 1 & +0.60 & -1.83 & = & +0.0062 & 1 \\ 1 & +0.60 & -1.83 & = & -0.0068 & 1 \\ 1 & +0.60 & -1.83 & = & -0.0328 & 1 \\ 1 & +0.61 & -1.83 & = & -0.0148 & 1 \\ 1 & +0.61 & -1.83 & = & +0.0112 & 1 \\ 1 & +0.62 & -1.83 & = & -0.0492 & 1 \end{array}$$

$$\begin{array}{llllll} & & & & & \text{Wt.} \\ 1.00x' & -0.73y' & -0.66\pi & = & -0^{\mathrm{R}}.027 & \frac{1}{2} \\ 1 & -0.72 & -0.71 & = & +0.002 & \frac{1}{2} \\ 1 & -0.72 & -0.73 & = & +0.016 & \frac{1}{2} \\ 1 & -0.72 & -0.79 & = & -0.048 & \frac{1}{2} \\ 1 & -0.71 & -0.89 & = & -0.016 & \frac{1}{2} \\ 1 & -0.70 & -0.91 & = & +0.029 & \frac{1}{2} \\ 1 & -0.46 & -0.71 & = & -0.010 & \frac{1}{2} \\ 1 & -0.45 & -0.66 & = & +0.018 & \frac{1}{2} \\ 1 & -0.45 & -0.63 & = & -0.014 & \frac{1}{2} \\ 1 & -0.44 & -0.58 & = & +0.019 & \frac{1}{2} \\ 1 & -0.44 & -0.52 & = & -0.029 & \frac{1}{2} \\ 1 & -0.44 & -0.50 & = & +0.081 & \frac{1}{2} \\ 1 & +0.10 & +0.03 & = & +0.012 & \frac{1}{2} \\ 1 & +0.12 & -0.14 & = & -0.012 & \frac{1}{2} \\ 1 & +0.14 & -0.19 & = & -0.055 & \frac{1}{2} \\ 1 & +0.15 & -0.18 & = & +0.007 & \frac{1}{2} \\ 1 & +0.15 & -0.18 & = & -0.001 & \frac{1}{2} \\ 1 & +0.16 & -0.17 & = & +0.009 & \frac{1}{2} \\ 1 & +0.60 & -0.08 & = & +0.043 & \frac{1}{2} \\ 1 & +0.60 & -0.15 & = & -0.001 & \frac{1}{2} \\ 1 & +0.60 & -0.12 & = & -0.038 & \frac{1}{2} \\ 1 & +0.61 & -0.09 & = & +0.019 & \frac{1}{2} \\ 1 & +0.61 & -0.06 & = & -0.014 & \frac{1}{2} \\ 1 & +0.62 & +0.05 & = & +0.020 & \frac{1}{2} \end{array}$$

If half-weight be assigned to those equations which depend on a single observation, the above equations of condition will reduce to the following five normals:

NORMAL EQUATIONS.

$$\begin{array}{rrrrrrl} +25.50x & -3.58y & +\ 0.00x' & +0.00y' & +\ 0.58\pi & +0^{\mathrm{R}}.0009 & = 0 \\ -\ 3.58 & +7.33 & +\ 0.00 & +0.00 & -\ 8.91 & -0.0096 & = 0 \\ +\ 0.00 & +0.00 & +12.00 & -1.26 & -\ 4.75 & -0.0020 & = 0 \\ +\ 0.00 & +0.00 & -\ 1.26 & +3.27 & +\ 2.30 & -0.0101 & = 0 \\ +\ 0.58 & -8.91 & -\ 4.75 & +2.30 & +77.05 & -0.1746 & = 0 \end{array}$$

A solution of these equations gives the following results:

$x = +0^{\mathrm{R}}.00060$
$x' = +0.00147$
$y = +0.00495 \pm 0^{\mathrm{R}}.0052 = +0''.063 \pm 0''.066$ Wt. 5.79
$y' = +0^{\mathrm{R}}.00163 \pm 0^{\mathrm{R}}.0071 = +0''.021 \pm 0''.090$ Wt. 3.09
$\pi = +0.00287 \pm 0.00159 = +0.0363 \pm 0.0202$ Wt. 62.73

the probable error of 1 observation being $\pm 0^{\mathrm{R}}.0126$ or $0''.159$

It will be noticed that the parallax here found is only about half the value given by Dr. CHANDLER'S theory, and yet, while the result does not positively corroborate, it is not of such a character as to render the theory improbable.

As a matter of interest an attempt was made to determine the proper motions of the comparison-stars, in order to find the absolute proper motion of *Algol*. For this purpose the observations of position-angle, which were made in the earlier part of the work, were also utilized.

The following table gives the several positions thus determined:

Star	Mag.	Catalogue	Epoch	Position 1892.0 A.R.	Position 1892.0 Decl.	Wt.
				h m s	° ′ ″	
a	7.3	Lalande 5630	1795.0	2 58 17.93	+40 42 1.1	½
		Weisse's Bessel II. 1335	1832.9	18.32	41 54.4	1
		Yale heliometer	1892.9	18.01	41 54.24	4
b	8.0	Weisse's Bessel II. 1388	1832.9	3 0 21.01	+39 47 4.9	½
		Yale heliometer	1892.9	20.91	4.67	4
c	7.8	Lalande 5716	1791.8	3 1 7.37	+41 10 13.6	½
		Paris 3730	1881.4	7.46	9.5	2
		Yale heliometer	1892.9	7.44	8.15	4
d	7.8	Lalande 5813	1795.0	3 4 21.22	+40 46 25.2	½
		Weisse's Bessel III, 1	1832.9	21.17	19.5	1
		Yale heliometer	1892.9	21.42	16.68	4

From Searle's position of *β Persei* (*Annals Harvard Observatory*, Vol. XXIX), using my observed distances and position-angles, the position of each comparison-star was calculated, and these positions compared with the places deduced from those found in the various catalogues at my disposal. The *Histoire Céleste* places were reduced by von Asten's tables, and the systematic corrections for the various catalogues given by Auwers in *Astr. Nachr.*, nos. 3195, 6 were applied.

Assigning to these places the weights given in the last column of the above table, and solving the resulting equations of condition by the method of least squares, I find the following annual proper motions:

Star	A.R.	Decl.
	s ″	″
a	−0.00161 = −0.024	−0.044
b	−0.00167 = −0.025	−0.003
c	+0.00081 = +0.012	−0.056
d	+0.00290 = +0.043	−0.072

It will be noticed that the declinations of the stars found in Lalande differ essentially from those of Weisse's Bessel and those since found, and the fair agreement of the latter would seem to indicate a systematic error in the former. The proper motions deduced from such uncertain data are therefore deserving of but little confidence.

The quantities y and y' may be expressed thus:

$$\begin{aligned} y = {} & (\Delta\alpha_d \cos\delta_d - \Delta\alpha_\beta \cos\delta_\beta)\sin p_{\beta d} + (\Delta\delta_d - \Delta\delta_\beta)\cos p_{\beta d} \\ & -(\Delta\alpha_a \cos\delta_a - \Delta\alpha_\beta \cos\delta_\beta)\sin p_{\beta a} - (\Delta\delta_a - \Delta\delta_\beta)\cos p_{\beta a} \\ y' = {} & (\Delta\alpha_b \cos\delta_b - \Delta\alpha_\beta \cos\delta_\beta)\sin p_{\beta b} + (\Delta\delta_b - \Delta\delta_\beta)\cos p_{\beta b} \\ & -(\Delta\alpha_c \cos\delta_c - \Delta\alpha_\beta \cos\delta_\beta)\sin p_{\beta c} - (\Delta\delta_c - \Delta\delta_\beta)\cos p_{\beta c} \end{aligned}$$

where $\Delta\alpha_a$, $\Delta\delta_a$, $\Delta\alpha_\beta$, etc., represent the annual proper motions in right-ascension and declination of the various stars, and $p_{\beta d}$, $p_{\beta a}$, etc., designate the position-angles of the different stars measured from β.

Using the above determined values for the proper motions of the comparison-stars with the values found for y and y' and their weights, and solving as by least squares, I find, for the absolute proper motion of β

$$\begin{aligned} \Delta\alpha \cos\delta &= -0''.032 \\ \Delta\delta &= -0\ .018 \end{aligned}$$

The values, obtained on the assumption that the comparison-stars have no proper motion, are

$$\begin{aligned} \Delta\alpha \cos\delta &= -0''.034 \pm 0''.035 \qquad \text{Wt. } 20.49 \\ \Delta\delta &= +0\ .014 \pm 0\ .046 \qquad \text{Wt. } 11.95 \end{aligned}$$

Comparing these results with those obtained by Dr. Chandler, according to his theory, viz:

$$\begin{aligned} \Delta\alpha \cos\delta &= +0''.0449 \\ \Delta\delta &= +0\ .0120 \end{aligned}$$

we are for the present hardly warranted in drawing any definite conclusions. The uncertainty in the proper motions of the comparison-stars has already been pointed out, and the absolute proper motion of *Algol*, as above determined, is therefore not very trustworthy. Furthermore, a year and half of heliometer observations is hardly sufficient in point of time to determine so small a relative proper motion with any great reliability, as is shown by the magnitude of the probable error. But by repeating the observations after an interval of five or six years, as is our present purpose, the accuracy of this latter quantity may be greatly increased, and in the course of time any change in the relative proper motion according to Chandler's theory could be detected.

Yale University Observatory, 1894 *April* 26.

MAXIMA AND MINIMA OF VARIABLE STARS OBSERVED IN 1892–1894.

(Extract from the Proceedings of the Bohemian Academy.)

By G. GRUSS and V. LÁSKA.

The following observations were made with an eight-inch equatorial instrument of the Bohemian University Observatory (Prague VII 80), by Argelander's method, and moreover independently from each other.

1) 845. *R Ceti.*

We have five observations of this star, from 1894 Feb. 4 to Feb. 22; from these is deduced

Max.: 1894 Feb. 20, 8$^{\text{M}}$.5.

2) 1574. *W Tauri.*

Eighteen observations of this star, from 1893 Oct. 18 to 1894 Apr. 3, show a maximum

1894 Feb. 20, 8$^{\text{M}}$.5.

3) 3493. *R Leonis.*

This star was under observation from 1893 Mar. 13 to July 4, the observations numbering eighteen. These give

Max.: 1893 July 1, 5$^{\text{M}}$.9.

The secondary maximum was observed twenty days before maximum. The brightness remained, about this epoch, constant from

1893 June 4 to June 14, 6$^{\text{M}}$.4.

4) 4948. *R Canum Venaticorum.*

From thirty-five observations between 1893 June 18 and 1893 Nov. 13, we obtain

Max.: 1893 Oct. 6, 6$^{\text{M}}$.1.

The secondary maximum was observed from

1893 Sept. 4 to Sept. 20, $6^{M}.5$.

5) 5194. *V Bootis.*

By fifteen observations, between 1893 Sept. 13 and 1893 Dec. 2, we deduce

Max.: 1893 Oct. 7, $6^{M}.8$.

The variations took place quite regularly.

6) 5438. *Y Librae.*

This star was observed twelve times, from 1893 June 22 to 1893 Aug. 18. We find quite certainly

Max.: 1893 July 3, $8^{M}.7$.

The period is 334 days.

7) 5677. *R Serpentis.*

From 1893 Sept. 13 to 1893 Nov. 13, thirteen observations were made, giving

Max.: 1893 Oct. 10, $7^{M}.0$.

8) 5758. *X Herculis.*

Twenty-one observations, between 1893 Sept. 10 and 1894 Jan. 11, give the following epochs:

Max.: 1893, end Sept., $6^{M}.3$.
Min.: 1893, end Nov., $6^{M}.9$.

Both epochs are uncertain.

9) 5889. *U Herculis.*

We observed this star from 1893 July 5 to 1893 Oct. 8, sixteen times, but without result.

10) 5950. *W Herculis.*

By twenty-five observations, from 1893 July 2 to 1894 Feb. 8, we obtain

Max.: 1894 Jan. 2, $8^{M}.0$.

The light-curve remained constant to the beginning of December. The change of light in the immediate neighborhood of the maximum was rapid.

11) 6088. *V Herculis.*

We observed this star from 1893 July 2 to Aug. 18. During the whole interval the star was *constant.*

12) 6682. *X Ophiuchi.*

Forty observations of this star, from 1893 June 17 to 1893 Dec. 20, show a maximum.

1893 Sept. 21, $6^{M}.8$.

One secondary maximum, $7^{M}.4$, was observed during August. CHANDLER's elements are

$$1886 \text{ April } 15 + 354\,E$$

instead of

$$1886 \text{ Jan. } 9 \quad + 290\,E$$

13) 6726. *T Aquilae.*

This star was under observation from 1893 June 16 to Dec. 20, the observations numbering forty-two. These give

Max.: 1893 Aug. 5, $8^{M}.7$.

14) 6834. *V Aquilae.*

We observed this star from 1893 Aug. 25 to Dec. 10, nineteen times, obtaining

Min.: 1893 Nov. 3, $7^{M}.5$.

The epoch of minimum is uncertain.

15) 6849. *R Aquilae.*

By thirty observations, from 1893 July 1 to Nov. 9, we obtain well determined

Max.: 1893 Aug. 10, $5^{M}.8$,

and one secondary maximum, $7^{M}.1$, thirty days after the principal one.

16) 6943. *T Sagittae.*

This star was observed three times by LÁSKA.

1893 Sept. 15, $8^{M}.3$
Oct. 17, $8^{M}.7$
Oct. 24, $8^{M}.9$

17) 7120 *χ Cygni.*

Twenty observations, made by GRUSS, from 1892 Aug. 21 to 1892 Oct. 11, with opera-glass, give

Max.: 1892 Sept. 18, $4^{M}.9$.

18) 7192. *Z Cygni.*

Nine observations, from 1893 Oct. 9 to 1893 Dec. 6, were made.* The maximum was passed.

19) 7261 *R Delphini.*

By twenty-eight observations, between 1893 Aug. 2 and 1894 Jan. 11, we deduce, quite certainly,

Max.: 1893 Oct. 4, $8^{M}.6$.

Two months before maximum this star was constant at $9^{M}.4$.

20) 7428. *V Cygni.*

This star was under observation from 1893 Dec. 2 to 1894 Feb. 22, the observations numbering fourteen. These give one maximum, $9^{M}.1$, between Dec. 30 and Jan. 11, not separately good.

21) 7444. *T Delphini.*

Eighteen observations, from 1893 Sept. 9 to 1894 Jan. 11, give

Max.: 1893 Sept. 23, $8^{M}.9$.

The light-curve increased rapidly, shortly before the maximum.

22) 7456. *RR Cygni.*

We observed this star from 1893 Sept. 13 to 1894 Feb. 22, twenty-three times, but not with separately good results. One maximum, 1893 Oct. 25, $8^{M}.3$, is uncertain.

23) 7459. *T Cygni.*

Eighteen observations, made by GRUSS, from 1892 Aug. 11 to 1892 Oct. 11, with opera-glass, give a good

Max.: 1892 Aug. 24, $5^{M}.1$.

24) 7795. *RV Cygni.*

This star was observed twenty-three times, from 1893 Sept. 13 to 1894 Feb. 2, and is probably of the β *Lyrae* type. The period is about 75 days. We have observed the following maxima and minima:

			M
1893	Max.:	Sept. 20,	7.65
	Min.:	Oct. 12,	7.75*
	Max.:	Nov. 5,	7.60
	Min.:	Nov. 16,	8.15**
	Max.:	Dec. 5,	7.65
	Min.:	Dec. 25,	7.70*
1894	Max.:	Jan. 20,	7.60
	Min.:	Jan. 30,	8.15**

25) 8068. *S Lacertae.*

Fifteen observations of this star, from 1893 Oct. 5 to 1894 Feb. 22, show a maximum,

1894 Jan. 25, $7^{M}.8$.

Prague, 1894 *April.*

A COMET IN THE CORONA OF 1893 APRIL 16.

In a paper read before the Astronomical Congress at Chicago, last August, immediately after my return from the Lick Observatory Eclipse-Expedition to Chile, particular attention was called to a comet-like structure visible on all the Lick Observatory negatives of the outer corona. As the interval of time between the first and last of these photographs was less than three minutes, a daily motion could not be determined with certainty. Two days ago we secured positive copies of the negatives taken by the English Expeditions to Brazil and Africa, and with the aid of the additional data thus furnished the suspected object is shown to be a comet, having at the time a daily geocentric motion of about three and one-quarter degrees away from the sun, in the position-angle 200°.

Lick Observatory, 1894 *May* 9. J. M. SCHAEBERLE.

GEOCENTRIC POSITIONS OF THE COMET OF 1893 APRIL 16,

BY J. M. SCHAEBERLE.

Since writing the note in which I announced the certain discovery of a comet in the corona of 1893 April 16, I have measured the coordinates of the center of the comet's head with reference to the center of the *Moon*.

As I am not yet in possession of the accurate location of the English eclipse-stations, nor of the exact times of exposure of the photographic plates, the measured coordinates may be in error by as much as two or three minutes of arc, when referred to the true position of the *Sun's* center. To orient the English photographs, the boundary of a very conspicuous and sharply defined streamer, which on my plates has the position-angle 82°.3 at 30′ from the *Sun's* center, was taken as a starting point for all the English plates. The scale of each photograph was separately determined by measuring the diameter of the *Moon's* image on each plate.

The evidence given by the positive copies of the negatives seems to prove that the comet was growing fainter with increasing distance from the *Sun*; for on the African plates the comet is very faint, while on my own negatives it forms a most conspicuous feature of the corona. These considerations render it almost certain that the object was actually within the visible limits of the corona, and that the *theoretical* perihelion passage occurred only a few hours before the photographs were taken.

POSITIONS OF THE COMET OF 1893 APRIL 16.

Place	Distance	Position Angle	$\Delta\alpha$	$\Delta\delta$
	′	° ′	s	′
Mina Bronces, Chile	40.0	199 45	−55.0	−37.6
Brazil	49.4	196 30	−57.0	−47.4
Africa	61.8	193 30	−58.7	−60.1

For the assumed Greenwich mean times given below the corresponding places of the *Sun* are obtained, from which the comet's coordinates are deduced by applying the proper $\Delta\alpha$ and $\Delta\delta$ given above.

Gr. M.T.	*Sun's* Apparent		Comet's Apparent	
	α	δ	α	δ
h m	h m s	° ′	h m s	° ′
1 3	1 39 15.2	+10 19.2	1 38 20.2	+9 41.6
2 16	1 39 26.5	+10 20.3	1 38 29.5	+9 32.9
3 38	1 39 39.2	+10 21.5	1 38 40.5	+9 21.4

In order to obtain some idea as to how accurately the comet could be located upon the plates, I requested Professor BARNARD to mark the several positions, on the glass sides of the photographs. My measurements of his positions agree almost exactly with those given above. The truly remarkable appearance of this particular object on my eclipse-negatives, so plainly showing an apparent connection with a singularly slender, but conspicuous streamer from the *Sun* (See sketch in "*Astronomy and Astro-Physics*" for April 1894) finally induced me to announce the "Mechanical Theory of Comets," as giving additional evidence in favor of the "Mechanical Theory of the Corona."

Lick Observatory, 1894 *May* 10.

OBSERVATIONS OF THE VARIABLE STAR β *LYRAE*,

By PAUL S. YENDELL.

Since May 1888 I have made more or less observations of β *Lyrae* during each season, but until the past winter have made no reduction of these observations, which have accumulated to the number of two hundred and fifty.

Although, from the nature of the star's light-curve, but a relatively small number of the observations are available for the determination of principal minima, several of the latter are indicated in each of the six years during which the observations have been carried on, excepting the year 1891, when the star was observed but three times.

In the reduction of these observations, I have made use of ARGELANDER's light-scale and mean light-curve, as published in his second treatise on the star (*De Stella β Lyrae Variabili Commentatio Secunda*, Bonn, 1859); and by this means have deduced thirty-four determinations of principal minima, distributed as follows: in 1888, thirteen; 1889, four; 1890, six; 1892, three; and in 1893, eight. The greatest number of observations available for the determination of any single minimum is five; and in the subjoined table, the weight 1 is assigned to those determinations depending on three or more observations, all others being given half weight only.

The minima observed are as follows: the residuals in the column O−C being obtained by a comparison with REED's elements, provisorily adopted by CHANDLER in his Second Catalogue.

OBSERVED MINIMA.

Epoch	Local Mean Time	W.	O−C	Epoch	Local Mean Time	W.	O−C
943	1888 May 7.769	½	−0.230	1005	1890 July 17.962	1	+0.241
944	20.439	½	−0.475	1007	Aug. 12.388	½	−0.262
945	June 3.315	1	+0.486	1008	25.086	½	−0.379
946	16.125	½	+0.381	1009	Sept. 7.617	½	+0.237
947	28.829	1	+0.171	1010	20.233	1	−0.061
948	July 11.507	½	−0.065	1012	Oct. 16.174	½	+0.050
949	24.644	½	+0.157				
952	Sept. 1.521	½	−0.121	1058	1892 June 1.239	1	+0.016
953	13.820	1	−0.427	1059	13.745	1	−0.394
954	27.601	½	+0.439	1061	July 9.790	½	−0.179
955	Oct. 9.255	½	−0.852				
958	Nov. 18.212	½	+0.492	1089	1893 July 6.525	½	−0.062
959	Dec. 1.285	½	+0.650	1090	19.404	1	+0.002
				1091	Aug. 1.364	1	−0.053
982	1889 Sept. 22.929	½	−0.747	1092	14.785	1	+0.452
983	Oct. 6.550	½	−0.040	1093	27.328	1	+0.080
986	Nov. 13.802	½	−0.524	1094	Sept. 8.953	½	−0.211
987	27.920	½	+0.669	1096	Oct. 4.786	½	−0.208
				1097	18.255	½	+0.346

Assembling the residuals in yearly groups, the corrections indicated are

		d	d
1888	E 950	+0.052	±0.109
1889	984.5	−0.135	±0.382
1890	1008.5	+0.0007	±0.272
1892	1059.3	−0.187	±0.147
1893	1093.8	+0.069	±0.170

The mean correction indicated for the period of six years, covered by the observations, is

$$E\ 1007.7\ \ +0^{d}.004311\ \ \pm 0^{d}.046$$

Taking all the observations together, the probable error of a single determination of minimum, of weight unity, appears to be $\pm 0^{d}.217$.

The above results seem to be substantially confirmatory of REED's elements, the probable error, in every case but one, being largely in excess of the indicated correction.

Dorchester, 1894 *May* 5.

FILAR-MICROMETER OBSERVATIONS OF COMET *a* 1894 (DENNING),

MADE WITH THE 23-INCH EQUATORIAL OF THE HALSTED OBSERVATORY, PRINCETON, N.J.,

BY TAYLOR REED.

1894 Greenwich M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
h m s			m s	′ ″	h m s	° ′ ″		
April 26 15 46 41	1	11	+0 7.87	. . .	11 19 17.07	. . .	9.327	. . .
16 14 12	1	6	. . .	−1 5.9	. . .	+16 53 4.5	. . .	0.461
May 7 17 19 45	2	1	+2 5.7	. . .	11 39 57.71	. . .	9.582	. . .
16 36 0	2	4	. . .	+0 12.0	. . .	+12 40 15.8	. . .	0.652
8 15 49 42	3	7	−0 35.96	. . .	11 41 27.91	. . .	9.411	. . .
15 43 25	3	8	. . .	+1 58.8	. . .	+12 19 47.1	. . .	0.638

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	11 19 7.35	+1.851	+16 54 15.5	−5.08	W.B. XI, 313
2	11 37 50.26	+1.752	+12 40 10.3	−6.46	W.B. XI, 623
3	11 42 1.11	+1.763	+12 17 55.0	−6.74	W.B. XI, 697*

* W.B. XI .697 = DM. 12°2378, where the right-ascension is given as about 10^s greater.

April 26. Light haze; comet faint and difficult to observe. — May 7. Clouds stopped observations.

All observations are corrected for refraction.

NEW ASTRONOMICAL WORK.

Die Venus-Durchgänge, 1874 *und* 1882; *Berichte über die Deutschen Beobachtungen, Fünfter Band*, 765 pp. *Berlin* 1893. A. AUWERS.

This volume presents the final reductions for the heliometer observations, made during the Transits of 1874 and 1882, by the parties sent out from Germany. In earlier volumes the preliminary details of these observations and of the reductions have been presented.

The first 325 pages of the present volume are taken up with discussions of the errors of the scales, screws, etc., for the four heliometers. Chapter XII presents a very extended discussion of the numerous results of meridian observations of the stars in the four arcs used for determination of scale-value, — a discussion which has a permanent value beyond the immediate purpose in view.

Chapter XV sets forth the details and results for the instructive series of measures, with the heliometer, of the apparent diameter of the sun, which were made not only at the various stations, but still more numerously at home. From these measures it results that the polar diameter exceeds the equatorial by 0″.038, or an elongation of 1:50000. The author attributes this anomalous result to a manifest tendency of the observers to measure vertical distances relatively greater than horizontal distances. On the other hand, although the indicated elongation is but little greater than its mean error, he considers that a flattening greater than 1:50000 is very improbable; and greater than 1:20000 wholly inadmissible.

In chapter XVI the Transit-measures are treated for the instrumental corrections deduced, and are finally brought to bear on the determination of the parallax. Extensive tables illustrate the contribution from each individual measure. The conditional equations are presented in like detail. The final solution gives

$$8''.8758 \pm 0''.0493$$

as the most probable result from the heliometer observations for the parallax. Several other nearly identical values are deduced through variety in treatment of the equations.

The author frankly expresses his opinion that modern research tends to a value for the solar parallax not likely to differ much from 8″.8. This supposition does not seem to him to be violently opposed to the heliometer-result, in view of the mean error of the latter. He points out, however, that this mean error is founded on a very complete discussion of all the elements of uncertainty; while in many instances no definite mean error can be assigned to determinations of the solar parallax, and in many others the statements of mean error presented are entirely illusory.

In chapter XVII, 16″.820 is given as the most probable result for the diameter of *Venus* (reduced to unit distance) that can be deduced from the heliometer-measures during transit.

An appendix discusses the results of the heliometer-measures made during the transit of 1882 by the polar expedition at South Georgia.

CORRIGENDA.

No. 315, p. 23, Mr. REED's Observations of Comet *a* 1894, *for* Apr. 6 *put* Apr. 5.

No. 317, p. 40, Ephemeris of Comet *b*, May 24.5 and 26.5, *for* $\alpha = 10^h\,59^m.3$ *put* $10^h\,39^m.3$; and *for* $11^h\,26^m.5$ *put* $10^h\,46^m.5$.

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No. 319.

VOL. XIV. BOSTON, 1894 JUNE 2. NO. 7.

A SUGGESTION IN THE THEORY OF *MERCURY*,

By A. HALL.

About forty years ago LeVerrier found that the line of apsides of the orbit of *Mercury* is in motion at the rate of 38″ a century more than the known forces will explain. Since then Professor Newcomb has made a new investigation of this question, and from a more extended series of observations has confirmed the result found by LeVerrier. Newcomb's result is a little greater, being 43″ a century. This anomalous motion in the line of apsides is the starting point of LeVerrier's theory of an intra-Mercurial planet, situated nearly in the plane of the orbit of *Mercury*. Several such planets have been supposed to be found; one by Dr. Lescarbault in 1859, with a period of 20 days, and others by Professors Watson and Swift in 1878. These discoveries, however, have not been confirmed to the satisfaction of astronomers. There are also theoretical objections to the introduction of such bodies, since they would disturb the motions of other planets. Some years ago Tisserand applied to this question Weber's theory of electro-dynamics, which would in fact produce a small part of the observed motion, but Weber's theory has, I think, been set aside by recent investigations in physics. Another explanation has been sought in the figure and constitution of the *Sun*, but in this case observations show the *Sun* to be almost exactly a spherical body. Thus, at present, no explanation of this motion remains.

If the Newtonian law of attraction is not a rigorous law of nature, or if it is modified slightly under certain conditions, probably this lack of rigor would become apparent first among the swiftly moving bodies of our solar system, such as our *Moon* and the planet *Mercury*. In his *Principia*, Book I, Newton has given some computations in which he assumes the law of attraction to be not exactly as the inverse second power of the distance. He shows that the perihelia would move under the action of such a central force; and on the other hand the observed fixity of the perihelia is a strong proof of his law of attraction. Laplace in his *Mécanique Céleste*, Book XVI, Chap. IV, has investigated some assumed changes of the law of attraction, and has shown in what terms of the *Moon's* motion these changes would become apparent. In 1873 Bertrand brought forward a more general question than that of Newton, and found an elegant expression for the angle between the smallest radius vector and the greatest, in the case of a body moving round a center of force in a closed curve; the attraction depending only on the distance. The central force has the form

$$R = mr^n$$

m being a constant, and r the radius vector. In the case of a small eccentricity the angle between the minimum and maximum radii is nearly

$$\theta = \frac{\pi}{\sqrt{n+3}}$$

If $n = -2$, we have the Newtonian law; the angle θ is 180°, or the particular radii form a right line, and so far as the action of the central force is concerned the perihelion is fixed. Applying Bertrand's formula to the case of *Mercury* I find, taking Newcomb's value of the motion, or 43″, that the perihelion would move as the observations indicate by taking

$$n = -2.00000016$$

It will be seen that a very small change in the law of central force would produce the required motion in the line of apsides. The question remains to examine the effect of this change on the other elements of the orbit. If we denote by μ the sum of the masses of *Mercury* and the *Sun* the equations of motion are

$$\left.\begin{aligned} \frac{d^2x}{dt^2} + \frac{\mu x}{r^{3+\Delta}} &= 0 \\ \frac{d^2y}{dt^2} + \frac{\mu y}{r^{3+\Delta}} &= 0 \\ \frac{d^2z}{dt^2} + \frac{\mu z}{r^{3+\Delta}} &= 0 \end{aligned}\right\} \qquad (1)$$

Cross multiplying by z, y, x, and taking the difference

1894AJ.....14...49H

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If $n = -2$, we have the Newtonian law; the angle θ is 180°; or the particular radii form a right line, and so far as the action of the central force is concerned the perihelion is fixed. Applying Bertrand's formula to the case of *Mercury* I find, taking Newcomb's value of the motion, or 43″, that the perihelion would move as the observations indicate by taking

$$n = -2.000\,000\,16$$

It will be seen that a very small change in the law of central force would produce the required motion in the line of apsides. The question remains to examine the effect of this change on the other elements of the orbit. If we denote by μ the sum of the masses of *Mercury* and the *Sun* the equations of motion are

$$\left.\begin{aligned} \frac{d^2x}{dt^2} + \frac{\mu x}{r^{3+\Delta}} &= 0 \\ \frac{d^2y}{dt^2} + \frac{\mu y}{r^{3+\Delta}} &= 0 \\ \frac{d^2z}{dt^2} + \frac{\mu z}{r^{3+\Delta}} &= 0 \end{aligned}\right\} \qquad (1)$$

Cross multiplying by z, y, x, and taking the difference

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of the products, we have complete differentials, and integrating,

$$(2)\qquad \begin{cases} \dfrac{zdy-ydz}{dt} = c_1 \\ \dfrac{xdz-zdx}{dt} = c_2 \\ \dfrac{ydx-xdy}{dt} = c_3 \end{cases}$$

c_1, c_2, c_3 are the three known areal constants of integration. It is almost self-evident that the node and inclination are not changed by the introduction of Δ. But this can be shown formally as follows. The rectangular coordinates of a planet in terms of its radius vector, true anomaly, and the constants; ω distance from node to perihelion, Ω the node, and i the inclination, are as follows:

$$x = r[\cos(v+\omega)\cos\Omega - \sin(v+\omega)\sin\Omega\cos i]$$
$$y = r[\cos(v+\omega)\sin\Omega + \sin(v+\omega)\cos\Omega\cos i]$$
$$z = r\sin(v+\omega)\sin i$$

If we multiply x by $\sin\Omega\sin i$, y by $-\cos\Omega\sin i$, and z by $\cos i$, and add the products, we have

$$x\sin\Omega\sin i - y\cos\Omega\sin i + z\cos i = 0$$

Because the velocities x', y', z', along the axes are linear quantities, we have likewise

$$x'\sin\Omega\sin i - y'\cos\Omega\sin i + z'\cos i = 0$$

These two equations give

$$\sin\Omega\tan i = \frac{yz'-zy'}{xy'-yx'}, = \frac{c_1}{c_3}$$
$$\cos\Omega\tan i = \frac{xz'-zx'}{xy'-yx'} = -\frac{c_2}{c_3}$$

These equations determine the node and inclination, which are therefore constant. If we multiply the equations of motion by $2dx$, $2dy$, $2dz$, add the products and integrate, then

$$(3)\qquad \frac{dx^2+dy^2+dz^2}{dt^2} - \frac{2\mu}{(1+\Delta)r^{1+\Delta}} + h = 0$$

h being the constant of integration. If we add the squares of equations (2) we find, after a little reduction, and putting $c_1^2+c_2^2+c_3^2 = k^2$.

$$(4)\qquad \frac{r^2(dx^2+dy^2+dz^2)}{dt^2} - \frac{r^2dr^2}{dt^2} = k^2$$

Eliminating the square of the velocity between equations (3) and (4), we have

$$(5)\qquad dt = \frac{rdr\,(1+\Delta)^{1/2}}{\sqrt{2\mu r^{1-\Delta}-(1+\Delta)r^2h-(1+\Delta).k^2}}$$

The two expressions for the element of the curve in space, in rectangular and polar coordinates, give

$$dx^2+dy^2+dz^2 = dr^2+r^2dv^2$$

and from equation (4)

$$dv = \frac{k.dt}{r^2} \qquad (6)$$

Substituting from (5) the value of dt,

$$dv = \frac{k(1+\Delta)^{1/2}.dr}{r\sqrt{2\mu r^{1-\Delta}-(1+\Delta)r^2h-(1+\Delta)k^2}} \qquad (7)$$

This equation shows that the maximum and minimum values of r are determined by the equation

$$r^2 - \frac{2\mu.r^{1-\Delta}}{(1+\Delta)h} + \frac{k^2}{h} = 0$$

Since Δ is small, let us put $\mu = \mu' r^\Delta$, and the equation becomes

$$r^2 - \frac{2\mu' r}{(1+\Delta)h} + \frac{k^2}{h} = 0$$

If the roots of this equation are $a(1+e)$, and $a(1-e)$, then

$$a = \frac{\mu'}{(1+\Delta)h}: \qquad a^2(1-e^2) = \frac{k^2}{h}$$

and inversely

$$h = \frac{\mu'}{(1+\Delta)a}: \qquad k = \sqrt{\frac{\mu' a(1-e^2)}{1+\Delta}}$$

With these values of h and k equation (7) gives

$$dv = \frac{\sqrt{a(1-e^2)}.dr}{r\sqrt{2r-\frac{r^2}{a}-a(1-e^2)}} \qquad (8)$$

The value of dv is in the common form, and the integral is

$$r = \frac{a(1-e^2)}{1+e\cos(v-\omega)} \qquad (9)$$

This is the polar equation of an ellipse, the pole being at the focus, and ω being the constant of integration. Equation (5) gives

$$dt = \frac{(1+\Delta)^{1/2}.rdr}{\sqrt{\mu'}.\sqrt{2r-\frac{r^2}{a}-a(1-e^2)}}$$

or

$$dt = \left(\frac{(1+\Delta)a}{\mu'}\right)^{1/2}\cdot\frac{rdr}{\sqrt{a^2e^2-(a-r)^2}}$$

If we assume $r = a(1-e\cos u)$ from which $a-r = ae\cos u$, then

$$dt = \left(\frac{1+\Delta}{\mu'}\right)^{1/2}.a^{3/2}(1-e\cos u).du$$

and integration gives

$$t+T = \left(\frac{1+\Delta}{\mu'}\right)^{1/2}.a^{3/2}(u-e\sin u) \qquad (10)$$

where T is the constant of integration. Equation (10) completes the solution. The relation between the eccentric anomaly u, and v, the true anomaly, will be found by equating the two values of the radius vector.

Hence the solution is simple, but it must be tried by comparison with observations. Taking the mass of *Mercury*

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$= \frac{1}{6000000}$, the mean distance $a = 0.3870988$, and computing the value of μ' from the value of a, I find

$$\log.\left(\frac{1+\Delta}{\mu'}\right)^{1/2} = 9.9999999584$$

The factor, therefore, by which equation (10) differs from the corresponding one under the Newtonian law, is so nearly unity that it seems possible such a change may be permitted by the observations.

The question may be raised whether the phenomenon which is sought to be explained is a real one. LeVerrier says: "The necessity of an increase in the secular motion of the perihelion of *Mercury* results exclusively from observations of the transits of the planet over the disk of the *Sun*. The exactitude of these observations is beyond doubt." Professor Newcomb has used the same kind of observations extended over a longer time. For my own part I cannot doubt the correctness of the increase of the secular motion found by these astronomers. Still, it would be well to have such an important result confirmed by meridian observations, or by referring the position of the planet to known stars.

1894 *May* 5.

SUPPLEMENT TO SECOND CATALOGUE OF VARIABLE STARS,

By S. C. CHANDLER.

This Supplement to the Second Catalogue (*A.J.* 300) is arranged in three tables, like the Supplement (*A.J.* 216) to the First Catalogue (*A.J.* 179–80). These tables conform strictly to the explanations in the preface to the Second Catalogue. The Catalogue and Supplement combined comprise 279 known variables, and furnish a full statement of our knowledge up to date, so far as is possible in so succinct a form. The elements of the Catalogue have been revised, and those for the newer stars have been supplied where possible, although some of the latter are rude.

There are signs of improvement in the positions of new variables currently announced, thus removing one source of annoyance and confusion to observers. The very moderate degree of accuracy required for this purpose is easy of attainment even by the most poorly equipped amateur. Perhaps it is not too much to hope that the coarse standards of precision of a round tenth of a minute in right-ascension and round minute in declination, will in future disappear.

There is urgent need that some observer should take up observation of variables visible only in the Southern hemisphere, and especially the independent confirmation of the stars found at the Boyden Observatory at Arequipa, and by Roberts in South Africa. The latter seems to have had unexampled success in finding, within a short time, a large number of variables which seem to belong exclusively to one interesting type, and he has assigned their periods with apparent exactness. It would be of great value if he would publish the details of the extremely interesting work he is so zealously prosecuting; as well as his methods of observation, and determination of elements.

The following stars are to be struck out of the list of "Unconfirmed Stars" in the Second Catalogue, since they have been confirmed, and will be found in Table I on the next page: — (1805), (2170), (6943), (7351), (7450), (7457), (7458), (8116); also (7784) which had already been transferred in the Second Catalogue (7783 *RU Cygni*). I am indebted to Prof. Kreutz for the note of this oversight. The following stars may also now be struck out of the same list, the first proving to be a mistaken announcement by the discoverer, and the others appearing to be constant, after careful watch by trustworthy observers: — (1220), (1948), (2305), (7020), (7280), (8100), (8499), (8617). Since the Catalogue was published Yendell has carefully observed all these objects, and his authority seems sufficient, in addition to Sawyer's and my own observations, to warrant their excision from the list.

The following are additional notes to some of the stars in the "Unconfirmed List" of the Second Catalogue.

(691) — *Persei.* Hartwig has assigned the letter *V* to this star. I abstained from applying any letter in the Catalogue, from suspicion of error in the original announcement of variability. Yendell, who has given it strict and continuous attention, is of the same opinion. The letter *V* has therefore been given to another star (980 *V Persei* in Table I). If there should hereafter prove to be a variable in or near the place of (691), it may receive, when confirmed, the next letter then unappropriated. This seems the best way out of the embarrassment, and affords a new example of the need of a conservative avoidance of precipitancy in assigning a definitive notation.

(1279) — *Camelopardalis.* The narrow extremes of brightness yet observed in this extraordinarily red and difficult star, do not yet exclude possibility of mistake. Every experienced observer is aware of the uncertainty of estimates in such cases, and there is no reason to think that photographic images can be relied upon any better. Mr. Yendell's counsel has been followed, by assigning no letter as yet. There would be equally good ground for lettering a large number of other red stars showing uncertain variations of the same unimportant type. These are common in the heavens. The result would be confusion beyond remedy.

(1801) — *Camelopardalis.* Correct position, (1855) $4^h\ 55^m\ 21^s$, $+68°\ 28'.2$.

(7238) — *Cygni.* There is still conflict between the observations of Espin, Deichmüller, Hartwig, Yendell, and myself.

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I. List of New Variables, Supplementary to the Catalogue

No.	Star	1900.0 R.A.	1900.0 Decl.	1900 Annual Variation		1855.0 R.A.	1855.0 Decl.	Redness	Magnitude Max.	Magnitude Min.
		h m s	° ′	s	′	h m s	° ′			
103	T Andromedae	0 17 10	+26 26.4	+3.12	+0.33	0 14 50	+26 11.4	–	8.2	13?
980	V Persei	2 43 15	+56 34.1	4.40	0.25	2 39 58	+56 22.6	5.0*	8.5	9.5?
1805	V Orionis	5 0 47	+ 3 58.0	3.16	+0.09	4 58 25	+ 3 51.0	4.2*	8.4	12<
2170	S Leporis	6 1 38	−24 11.2	2.47	0.00	5 59 47	−24 11.1	–	6.7	7.5
5174	RS Virginis	14 22 18	+ 5 7	3.00	−0.27	14 20 3	+ 5 19	–	8.2	12?
5511	RS Librae	15 18 30	−22 34	3.50	0.22	15 15 53	−22 24	–	8.4	<11
5533	R Normae	15 22 11	−50 13.9	4.31	0.21	15 18 57	−50 4.4	–	7?	–
6062	RR Scorpii	16 50 16	−30 25.7	3.82	0.10	16 47 24	−30 21.1	–	7.3–7.7	11.6
6207	Z Ophiuchi	17 14 28	+ 1 37.3	3.04	−0.07	17 12 12	+ 1 40.3	3.0	8.2	12.5
6900	W Aquilae	19 10 0	− 7 13.2	3.23	+0.10	19 7 34	− 7 17.6	–	8.5	12?
6943	T Sagittae	19 17 14	+17 28.1	2.68	0.11	19 15 13	+17 23.2	5.5*	8.3	9.9
7139	RR Sagittarii	19 49 43	−29 27.2	3.74	0.15	19 46 54	−29 34.0	–	7.5	<12.5
7247	RX Cygni	20 7 46	+47 30.9	1.84	0.18	20 6 24	+47 23.0	–	7.5	8.3
7351	RW Cygni	20 25 12	+39 38.8	2.18	0.20	20 23 34	+39 29.9	7.0*	7.7	10.5
7448	W Aquarii	20 41 10	− 4 26.9	3.15	0.22	20 38 48	− 4 36.6	–	8.0	9.6
7450	V Aquarii	20 41 46	+ 2 4.2	3.04	0.22	20 39 29	+ 1 54.6	2.5*	8.1	9.3
7458	V Delphini	20 43 14	+18 58.0	2.72	0.22	20 41 11	+18 48.3	–	8.9–9.1	12?
8116	W Cephei	22 32 39	+57 54.4	2.28	0.31	22 30 56	+57 40.5	4.5*	7.3	8.3
8324	V Cassiopeae	23 7 22	+59 8.4	+2.56	+0.33	23 5 27	+58 53.8	–	8.3	12

Notes to Table I.

No.	Discovered	Confirmed	No.	Discovered	Confirmed
103	Anderson, 1893 ;	Hartwig, Fleming	1895	Boss, 1887 ;	Yendell
980	Espin, 8193 ;	Yendell	2170	Sawyer, 1891 ;	Yendell

II. Additions and Corrections to the Elements of the Catalogue in No. 300.

No.	Star	*M—m*	Elements of Maximum, Greenwich M.T. Epoch (Cal.)	(Julian)	Period	Inequalities	Remarks	Basis of Elements *M*	*m*	Dates included
				d	d					
114	S Ceti	145	1873 Jan. 6 =	240 5165	+320.0 E			8	3	1872–94
678	U Persei	–	. . . . .	. . . . .	. . .	Irregular				
1113	U Arietis	–	1892 Oct. 28	241 2400	+383 E			2	–	1892, 93
1574	W Tauri	78	1880 Feb. 5	240 7751	+142.0 E			5	2	1880, 87–94
1717	V Tauri	89	1872 Sept. 3	240 5040	+170.0 E	+25 sin(2°.4 E+60°)		19	6	1826, 54, 71–94
1981	S Camelopard.	150 :	1892 July 20	241 2300	+300 E?			3	3	1892–94
2100	U Orionis	145 :	1885 Dec. 1	240 9877	+375 E	Periodic inequality		9	1	1885–94
2258	V Aurigae	–	1886 Dec. 4	241 0245	+313 E?			5	–	1886, 91–93
2266	V Monocerotis	–	*For* Feb. 14 *put* Feb. 1							
2528	R Geminorum	121	1868 Feb. 7	240 3370.0	+370.2 E	+35 sin(6° E+78°)		21	7	1796, 1855–93
4847	S Virginis	–	*For* 240 7512 *put* 239 7512							
5338	U Bootis	90	1880 Mar. 11	240 7786.0	+176.7 E	Periodic inequality		12	7	1857, 80-94
5438	Y Librae	–	1861 July 22	240 0979	+325 E			5	–	1861, 78, 87–93
5758	X Herculis	60	1890 July 4	241 1553	+ 92.5 E			8	8	1890–93
5776	X Scorpii	–	*For* 240 0634 *put* 240 6364							
5887	V Ophiuchi	–	1874 May 26	240 5670	+302.5 E			9	–	1874–93
6044	S Herculis	–	Elements give phases 40ᵈ to 50ᵈ too early							
6682	X Ophiuchi	140 :	1886 May 7	241 0034	+330 E?			5	3	1886–93
6923	Z Sagittarii	–	1888 Aug. 10	241 0860	+450 E?			2	–	1888, 93
7085	RT Cygni	100 :	1887 Sept. 5	241 0520	+189.5 E			4	2	1842, 87–93
7234	R Capricorni	–	Strike out remark "Elements uncertain"							
7252	W Capricorni	87 :	1872 July 10	240 4985	+207.7 E			9	1	1872–91
7444	T Delphini	–	1864 Sept. 16	240 2133	+331.2 E			17	–	1855, 63–93
7456	RR Cygni	40 :	1888 May 8	241 0766	+166 E			4	2	1888–93
7488	Y Cygni	–	MIN. Even 1886 Dec. 9d 11h 10m.8 + 1d 11h 57m 27s.6 E MIN. Odd 1886 Dec. 9 9 57 .0 + 1 11 57 15 .2 E				Dunér	–	91	1886–93
7733	Y Capricorni	–	Strike out remark "Elements uncertain"							
7783	RU Cygni	240 :	1890 May 6	241 1484	+396 E?			4	3	1890–93
8068	S Lacertae	–	1891 July 18	241 1934	+154 E			3	–	1891–94

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No.	M—m	Elements of Maximum, Greenwich M.T. Epoch (Cal.)	(Julian)	Period	Inequalities	Remarks	Basis of Elements M	m	Dates included
			d	d					
103	–	. . . .		. . . . .			–	–	
980	–	. . . .		. . . . .			–	–	
1805	–	1891 Feb. 14 =	241 1778	+266 E ?			2	–	1891, 94
2170	–	. . . .		. . . . .	Irregularly periodic		–	–	
5174	–	1890 May 22	241 1510	+366 E			4	–	1890–94
5511	–	1889 July 9	241 1193	+222 E			4	–	1889–92
5533	–	. . . .		. . . . .			–	–	
6062	–	1887 July 25	241 0478	+278 E	Pickering's elements		–	–	
6207	–	1893 May 1	241 2585	+348.4 E	" "		–	–	
6900	–	. . . .		. . . . .			–	–	
6943	65	1885 Dec. 10	240 9886	+177 E ?			5	1	1855, 56, 85–92
7139	140	1891 Sept. 26	241 2002	+338 E			3	4	1879–92
7247	–	. . . .		. . . . .	Short period, or irregular		–	–	
7351	–	. . . .		. . . . .			–	–	
7448	–	1888 Dec. 12	241 0984	+300 E ?			2	–	1888, 93
7450	123	1891 Jan. 15	241 1748	+245 E			3	4	1890–93
7458	–	1890 Dec. 20 =	241 1722	+360 E			2	–	1890, 93
8116	–	. . . .		7.25	Yendell's period		–	–	
8324	–	. . . .		. . . . .			–	–	

NOTES TO TABLE I.

No.	Discovered	Confirmed	No.	Discovered	Confirmed
5174	Fleming, 1892 ;	Hartwig	7247	Deichmüller, 1893 ;	Yendell
5511	Fleming, 1892 ;	Chandler	7351	Espin, 1885 ;	Yendell
5533	Fleming, 1893 ;	Campbell	7448	Fleming, 1891 ;	Hartwig
6062	Thome, 1892 ;	Fleming, Yendell	7450	DeBall, 1891 ;	Yendell
6207	Fleming, 1893 ;	Yendell, Chandler	7458	Fleming, 1891 ;	Yendell, Hartwig
6900	DeBall, 1893 ;	Schwab	8116	Espin, 1885 ;	Yendell, J. A. Parkhurst
6943	Espin, 1886 ;	Yendell, Chandler	8324	Anderson, 1893 ;	Hartwig
7139	Thome, 1891 ;	Fleming			

III. STARS AWAITING CONFIRMATION, SUPPLEMENTARY TO THE LIST IN THE CATALOGUE IN No. 300.

No.	Star	1855.0 R.A.	Decl.	Supposed limits	Observer	Remarks
		h m s	° ′	M M		
(62)	—Sculptoris	0 8 2	−32 51.1	6.5–10.0	Fleming	"Max. 1846 Sept. 22+366 E"
(118)	ξ Tucanae	0 17 35	−72 40	–	Fleming	6 variables in the cluster (*A. N.* cxxxv, 130)
(780)	—Persei	2 6 53	+57 51.2	8.7– ?	Hartwig	Wolf's and Yendell's observations favor
(2083)	—Columbae	5 45 27	−29 20	7.9–11.4<	Fleming	
(3040)	—Carinae	8 25 46	−59 38.3	7.2– 8.0	Roberts	"Period, $6^{d}.66$"
(3055)	—Carinae	8 28 8	−58 44.1	7.8– 8.6	Roberts	"Max. 1893 Feb. 22.3+6.52 E"
(3416)	—Velorum	9 27 45	−44 34.1	7.7– 9.3	Woods	*Algol*-type ?
(3767)	—Carinae	10 27 44	−57 45.1	7.8– 8.6	Roberts	"Max. 1894 Feb. 9.2+3.637 E"
(5159)	—Bootis	14 17 40	+26 22.0	7.2– 8.2 ?	Hartwig	"Period more than 2 years"
(5750)	—Triang. austr.	15 54 27	−62 30.6	7.7– 8.7	Roberts	"Max. 1894 Feb. 7.7+2.546 E"
(6101)	—Scorpii	16 53 47	−36 36	9.2–12.9<	Fleming	
(6500)	—Pavonis	17 58 57	−63 38.2	7.6– 9.0	Fleming	Cordoba data favor var. $(7^{M}\frac{1}{2}–9^{M}\frac{1}{2})$
(6653)	—Lyrae	18 27 19	+36 53.1	7.2– 7.8	Birmingham and Safarik :	Espin's and Wolf's phot. favor
(6699)	—Draconis	18 35 38	+55 28.6	8.5– ?	Espin	H. C. O. photographs show no var.
(6716)	—Lyrae	18 37 49	+36 49.4	7.2– 7.6	Safarik	Espin's and Wolf's phot. favor $(8^{M}.8, 10^{M}.2)$
(6769)	—Sagittarii	18 45 30	−22 48.0	9.7 ?	Safarik	Red : fainter one of a pair
(6894)	—Lyrae	19 7 16	+25 45.6	9.0–12.0	Espin	
(6897)	—Cygni	19 8 27	+49 24.2	8.7–10.2 ?	Deichmüller	Hartwig's observations favor
(7118)	—Aquilae	19 44 17	+ 4 5.9	8.5–<12	Fleming	"Period about one year"
(7492)	—Cygni	20 47 9	+46 47	9.1– 13	Espin	

1894	α	δ	log Δ	Brightn.
	h m s	° ′		
May 26.5	10 44 41	+36 12.6	9.9120	0.77
28.5	51 28	37 16.7	.9383	
30.5	10 57 46	38 11.7	.9632	0.57
June 1.5	11 3 41	38 59.1	9.9867	
3.5	9 17	39 40.0	0.0090	0.43
5.5	14 37	40 15.3	.0301	
7.5	11 19 42	+40 46.0	0.0502	00.33
June 9.5	11 24 35	+41 12.7	0.0692	
11.5	29 16	41 35.8	.0873	0.26
13.5	33 47	41 55.9	.1046	
15.5	38 10	42 13.3	.1211	0.21
17.5	42 26	42 28.3	.1368	
19.5	46 35	42 41.2	.1518	0.17
21.5	11 50 37	+42 52.2	0.1662	

1894 *May* 24.

SECOND PERIODIC COMET OF TEMPEL, 1873 II = 1878 III = *c* 1894.

This comet was found by FINLAY, May 8, remarkably close to the position assigned by SCHULHOF's ephemeris.

Mr. SCHULHOF has now corrected the elements by the new observations, and publishes in *A.N.* 3229 the resultant corrections to the ephemeris. Applying these, we have

EPHEMERIS FOR WASHINGTON MIDNIGHT.

1894	α	δ	log Δ	$1:r^2\Delta^2$
	h m s	° ′		
June 3.5	1 4 17	−0 9.5		
4.5	7 7	−0 0.2	0.21611	0.182
5.5	1 9 57	+0 9.1		
June 6.5	1 12 46	+0 18.2	0.21552	
7.5	15 33	0 27.1		
8.5	18 18	0 35.9	0.21492	0.179
9.5	21 3	0 44.6		
10.5	23 48	0 53.1	0.21432	
11.5	26 31	1 1.5		
12.5	29 11	1 9.8	0.21371	0.177
13.5	31 35	1 17.9		
14.5	34 36	1 25.8	0.21309	
15.5	37 15	1 33.6		
16.5	1 39 53	+1 41.3	0.21246	0.174

NEW ASTRONOMICAL WORK.

Publications of the Washburn Observatory of the University of Wisconsin. Vol. VIII.

This volume contains, in Part 1, the results of the meridian-circle observations made in the years 1888–1890 by Professor S. J. BROWN, U.S.N., assisted by ALBERT S. FLINT and H. V. EGBERT, as prepared for publication by Prof. GEORGE C. COMSTOCK.

The original plan contemplated determinations of the positions of the *Zusatzsterne* of AUWERS's *Fundamental-Catalog*, but during the progress of the work the greater part of the stars of that catalogue received determinations. The right-ascensions depend upon those of the *Berliner Jahrbuch*, nos. 1 to 336; the declinations are independent.

The polar deviation of the instrumental meridian was derived from the tabular right-ascensions for which daily ephemerides are given in the *Jahrbuch*, or the measures were reduced to this standard. The right-ascensions are examined with reference to a variety of sources of personal and instrumental error, with generally satisfactory results.

The zenith-distance observations are corrected for division-error and flexure. The division-error was determined for diameters at intervals of 10′, and a table of corrections is formed by means of a systematic adjustment. Professor COMSTOCK infers that the probable error of the mean reading for four microscopes due to outstanding division-error, is ±0″.04. The Pulkowa refraction-tables are employed in the reductions. A careful discussion of the indications of the thermometers, together with a comparisons of the results for latitude, at different distances from the pole, leads to the conclusion that the adopted refractions need no material correction for the Madison observations.

Professor COMSTOCK finds for the probable errors in R.A. and Decl. respectively:

$$\pm 0^s.019 \sec\delta\,(\sec z\,)^{1/7}\ ;\ \pm\sqrt{(0''.35)^2+(0''.115\tan z)^2}$$

comparing the declinations with those of the *Berliner Jahrbuch*, a well marked difference depending upon R.A. is found, with a range of values approximating 1″. Arranged in order of declination, the systematic differences are smaller. The largest (*M—B.J.* = —0″.3) are found in declinations from +5° to +30°.

Neither the individual nor the mean results of the determinations are given directly; but they are presented in the form of corrections to the places in the *Jahrbuch*.

Part 2 of this volume contains the results of observations, by Professor COMSTOCK and Mr. FLINT, of *Mars* at its opposition in 1892. The programme of Professor EASTMAN was followed, except that the distance of the parallel wires used in bisections of *Mars* was 11″, instead of 16″. The observations of *Mars* are 59 in number.

The use of the reversing prism revealed decided discrepancies of a variable nature between those which were made in the ordinary way without the prism, and those in which the direction of the apparent zenith was reversed by the use of the prism. For each of the observers the variation of these differences is stated to have been a little greater than 1″. For the greater part of the observations the prism was used, and therefore no correction for error of bisection is applied in those results.

CORRIGENDUM.

No. 318, p. 48, Right-ascension of comet, May 8, *for* $11^h\,41^m\,27^s.91$ *put* $11^h\,41^m\,26^s.91$

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NEW ASTRONOMICAL WORK.
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VARIATION OF LATITUDE FROM THE GREENWICH MURAL-CIRCLE OBSERVATIONS, 1836–51,

By S. C. CHANDLER.

The remarkably satisfactory results obtained from Pond's work with the Mural Circles, from 1825 to 1836, has encouraged me to discuss the continuation of the series under Airy's directorship, from 1836 to 1851. For this interval, however, the work has not the homogeneous character that it had under Pond. Pond's method of operating the instruments conjointly, described in no. 313, was continued unchanged until 1839 February 24, by Airy; who then, seeing no advantage in the simultaneous use of two like instruments, gave up the Jones Circle, which was sent to the Cape of Good Hope, in exchange for the damaged Cape Circle. Thereafter the Troughton Circle, provided with a telescope-micrometer with fixed and movable threads, was employed alone; but direct and reflected observations were still obtained at the same culminations. Six microscopes were used, except between 1843 Sept. 15 and 1844 Mar. 21, during which time the microscopes were removed and repaired, in successive groups of three; meanwhile leaving the other three equidistant microscopes for observation. After the last date mentioned the readings of the six were resumed. The use of the fixed wire was also changed, in 1843, for that of the movable wire, in the telescope-micrometer. No other change of importance took place until 1848 May 10, when the instrument was temporarily dismounted, for the purpose of installing the Transit-Circle. The Jones (Cape) Circle, which had meanwhile been repaired, was used as a substitute, while the Troughton Circle was remounting on the east wall of the rooms below the library, under a shed prepared for it. The new location was 48 feet east and 10 feet south of its former position. Here the observations were continued with it, from 1848 July 21 to the end of 1850, when the employment of the Mural Circles was definitively abandoned.

The record of these changes is important, as they have a distinct bearing on our discussion, as hereafter shown.

The material chosen for discussion is practically all that can be advantageously used, and comprises all the observations, of the 43 stars in the following table, for which direct and reflected pointings were obtained at the same culmination. These give, of course, the absolute altitudes, eliminating the index-error, as in the Pond series. Thus we have 4353 observations distributed as shown in the table. All the stars used in the Pond series were included, except numbers 11 and 14 (*α Canis minoris* and *γ Leonis*), which were very insufficiently observed after 1835. In addition we have the nine stars whose numbers have the suffix "*a*" in the table. While the material is by no means so ample as Pond's, it is more uniformly spread over the whole interval of time.

No.	Star	α	δ	n	No.	Star	α	δ	n
		h	°				h	°	
1	*α Andromedae*	0.0	28.2	60	9*a*	51 *Cephei U.C.*	6.3	87.3	35
2	*γ Pegasi*	0.1	14.2	24	9*a*	" *L.C.*	6.3	87.3	25
2*a*	*β Cassiopeae*	0.0	58.2	47	10	*α² Geminorum*	7.4	32.3	55
3	*α Cassiopeae*	0.5	55.6	132	12	*β Geminorum*	7.6	28.4	75
4	*α Ursae minoris U.C.*	1.0	88.4	192	13	*α Leonis*	10.0	12.8	79
4	" " *L.C.*	1.0	88.4	233	15	*α Ursae Majoris*	10.9	62.7	175
5	*α Arietis*	1.9	22.7	44	16	*δ Leonis*	11.1	21.5	56
6	*α Tauri*	4.4	16.2	68	16*a*	*γ Ursae Majoris*	11.7	51.6	85
7	*α Aurigae*	5.1	45.8	183	17	*δ Ursae Majoris*	12.1	58.0	93
8	*β Tauri*	5.3	28.5	48	17*a*	*ε Ursae Majoris*	12.8	56.9	82
9	*α Orionis*	5.8	7.4	33	18	*α Draconis*	14.0	65.2	66

No.	Star	α	δ	n	No.	Star	α	δ	n
		h	°				h	°	
19	*α Bootis*	14.1	20.1	208	27	*β Lyrae*	18.7	33.2	93
20	*ε Bootis*	14.6	27.8	61	28	*ζ Aquilae*	19.0	13.6	54
21	*β Ursae minoris U.C.*	14.9	74.8	191	29	*δ Draconis*	19.2	67.4	56
21	*β Ursae minoris L.C.*	14.9	74.8	19	30	*γ Aquilae*	19.6	10.2	42
22	*α Coronae*	15.5	27.3	71	31	*α Aquilae*	19.7	8.4	69
23	*α Serpentis*	15.6	7.0	25	32	*β Aquilae*	19.8	6.0	49
23*a*	*η Draconis*	16.4	61.9	117	32*a*	*λ Ursae minoris U.C.*	20.5	88.8	53
24	*α Herculis*	17.1	14.6	32	32*a*	" " *L.C.*	20.5	88.8	13
24*a*	*ε Ursae minoris U.C.*	17.1	82.3	74	33	*α Cygni*	20.6	44.7	196
24*a*	" " *L.C.*	17.1	82.3	14	34	*α Cephei*	21.2	61.9	182
25	*α Ophiuchi*	17.5	12.7	75	35	*β Cephei*	21.4	69.8	105
25*a*	*δ Ursae minoris U.C.*	18.4	86.6	105	36	*α Pegasi*	22.9	14.3	57
25*a*	" " *L.C.*	18.4	86.6	23	36*a*	*γ Cephei*	23.5	76.7	109
26	*α Lyrae*	18.5	38.6	370		Total			4353

As regards reduction, I have corrected all the observations, as they are given in the tables of individual north polar distances in the Greenwich volumes, so as to correspond to the same values of the astronomical constants as I adopted for the reduction of Pond's observations; namely, the Pulkowa precession and nutation, the aberration 20''.500, and Boss's proper motions. The refractions needed no correction, as Bessel's tables were adopted by Airy from the beginning of his Greenwich administration. It is desirable to specify in detail how these corrections were effected.

To reduce to the constants above adopted, the Greenwich north polar distances require the following corrections.

Since the original reduction was to Jan. 1.0 of each year, for the Greenwich meridian, the reduction to the beginning of Bessel's fictitious year is, $\Delta E = +0''.055\ \kappa \cos\alpha$; where κ is the interval in fractions of a day to refer to $\odot = 280°$.

From 1836–49, inclusive, Bessel's old constant of precession, 20''.0426, was used at Greenwich. Hence the reduction is $\Delta P = +0''.015\ \tau \cos\alpha$.

No proper motions were used at Greenwich for reduction to mean place, for any of our stars except *α Bootis* and *β Aquilae*. Putting for these stars, $\mu' = -0''.04$ and $+0''.03$, respectively, as the differences from Boss's proper motions, and for the other stars Boss's values of μ', we have, $\Delta\mu' = \tau\mu'$.

From 1836–49, the Greenwich observations were reduced with the aberration-constant 20''.36; for 1850, with 20''.42. Putting then, from 1836–49,

$$m \sin M = -0''.14\ (\sin\varepsilon \cos\delta - \cos\varepsilon \sin\alpha \sin\delta)$$
$$m \cos M = -0''.14 \cos\alpha \sin\delta$$

and for 1850 changing $-0''.14$ to $-0''.08$, we have the correction for aberration, $\Delta k = m \sin(\odot + M)$.

If we take the differences between the expressions for the nutation used in the Nautical Almanacs from 1836–50, and those of Peters, and write them, transformed for convenience, into

$$\begin{aligned}\Delta r = &+0''.0241 \sin(\Omega - \alpha) &&+0''.0509 \cos\alpha \sin(\odot - \Gamma)\\ &+0''.0059 \sin(\alpha - 2\odot) &&\ \ 0''.0089 \sin(\odot + \Gamma - \alpha)\\ &+0''.0004 \sin(\odot + \Gamma + \alpha) &&+0''.0023 \sin(\alpha + \Omega)\\ &+0''.0004 \sin(\alpha + 2\odot)\end{aligned}$$

then, neglecting insignificant terms, and putting with sufficient accuracy, $\Omega = (1839.0 - t)\ 19°.34$, $\Gamma = 280°$, we have the correction for nutation,

$$\begin{aligned}\Delta r = &+0''.024 \sin[(1839.0 - t)\ 19°.34 - \alpha]\\ &+0''.051 \cos\alpha \sin(\odot - 280°)\end{aligned}$$

It will be seen that the terms depending on ☾ and 2☾ have been neglected. This can be done with safety, as their effect on the mean polar distances as hereafter taken in groups of 10 or 12 days, for each star, will rarely be as much as 0''.01 or 0''.02; and that on the values of $\Delta\varphi$ obtained by combining the stars in very different right-ascensions will be very far below those limits.

From 1836 to 1843, inclusive, the Greenwich reductions were made with $\varphi = 51°\ 28'\ 39''.00$; from 1844 to 1850, inclusive, with 51° 28' 38''.20. From 1848 July 21 to the end of 1850, the change in the location of the instrument, $\Delta\varphi = -0''.10$, was ignored. From a provisional discussion of the six polars in our lists, I obtained $\varphi = 51°\ 28'\ 38''.37$, so that the reduction for latitude, $(-\Delta\varphi)$, is; 1836–43, $+0''.63$; 1844–48 July 21, $-0''.17$; afterwards, $-0''.27$.

For convenience the same equinox was chosen as for the Pond series, 1830.0. Calling P_0 the annual precession for the middle date, the reduction to equinox is $\Delta P_0 = (\text{Year} - 1830)\ (P_0 + \mu')$. Of course the higher terms of the precession, and the secular variation of proper motions, were rigorously allowed for in the polar stars.

I cannot find that, in any of the Greenwich reductions, the reflected observations were reduced to the center of the instrument. Therefore we must apply the further correction, $+0''.046 \tan\zeta$.

The collective correction to the Greenwich polar distances is therefore

$$\Delta(\Delta) = \Delta E + \Delta P + \Delta\mu' + \Delta k + \Delta r \mp \Delta\varphi + \Delta P_0 \pm 0''.046 \tan\zeta$$

The double signs are for *U.C* and *L.C.*, respectively.

This correction being conveniently tabulated for each of the 43 stars, was applied to the Greenwich values of polar distance, after they had been combined in ten or twelve-day groups; the results being then expressed in declination.

From this point the treatment, by means of two approximations, for the purpose of getting normal mean values of $\varphi - \varphi_0$ for a series of dates 60 days apart, was so nearly like that adopted for the Pond series — fully explained in no. 315 — that I need here only give the resulting table, which is exactly in the form of that on p. 18. The horizontal rules indicate the points where it will be necessary to divide the equations, in the solutions to be given, in order to eliminate the effect of any possible constant differences caused by the changes in the modes of observation described in the beginning of this article.

t		Number		$\varphi - \varphi_0$	
Calendar	Julian	Obs.	Stars	Obs.	Comp.
1836 Jan. 6	= 2391650	35	12	+0.10	−0.01
Mar. 6	1710	63	16	+ .17	− .05
May 5	1770	82	8	+ .18	+ .03
July 4	1830	66	11	+ .07	+ .15
Sept. 2	1890	62	9	+ .13	+ .20
Nov. 1	1950	56	10	+ .03	+ .11
Dec. 31	2010	31	11	− .42	− .03
1837 Mar. 1	2070	24	13	− .23	− .10
Apr. 30	2130	41	12	− .09	− .02
June 29	2190	42	14	+ .04	+ .15
Aug. 28	2250	61	15	+ .22	+ .21
Oct. 27	2310	83	17	+ .10	+ .17
Dec. 26	2370	41	16	+ .26	.00
1838 Feb. 24	2430	21	15	− .08	− .13
Apr. 25	2490	47	13	+ .03	− .08
June 24	2550	42	12	+ .09	+ .08
Aug. 23	2610	51	16	+ .16	+ .24
Oct. 22	2670	67	21	+ .27	+ .23
Dec. 21	2730	50	16	+ .10	+ .06
1839 Feb. 19	2790	41	16	− .11	− .16
Apr. 20	2850	40	11	+ .02	− .17
June 19	2910	62	16	− .20	− .03
Aug. 18	2970	64	16	+ .09	+ .13
Oct. 17	3030	74	21	+ .06	+ .17
Dec. 16	3090	65	24	− .08	+ .06
1840 Feb. 14	3150	96	20	− .24	− .10
Apr. 14	3210	62	17	− .40	− .15
June 13	3270	57	20	− .17	− .06
Aug. 12	3330	62	18	+ .13	+ .07
Oct. 11	3390	84	20	− .14	+ .12
Dec. 10	3450	65	20	.00	+ .06
1841 Feb. 8	3510	29	10	− .21	− .05
Apr. 9	3570	50	17	− .12	− .10
June 8	3630	49	22	.00	− .01
Aug. 7	3690	41	15	+ .04	+ .05
Oct. 6	3750	49	19	+ .28	+ .08
Dec. 5	3810	41	13	+ .22	+ .02
1842 Feb. 3	3870	37	13	− .23	− .06
Apr. 4	3930	37	13	− .46	− .07
June 3	3990	61	20	− .31	+ .01
Aug. 2	4050	83	18	− .18	+ .08
Oct. 1	4110	55	18	.00	+ .08
Nov. 30	4170	58	18	− .23	− .01
1843 Jan. 29	4230	30	12	− .16	− .11
Mar. 29	4290	36	15	− .02	− .10
May 29	= 2394350	34	18	−0.14	+0.02
1843 July 28	= 2394410	52	17	+0.18	+0.13
Sept. 26	4470	116	21	+ .23	+ .13
Nov. 25	4530	51	17	+ .10	.00
1844 Jan. 24	4590	60	13	− .30	− .14
Mar. 24	4650	90	24	− .17	− .16
May 23	4710	72	23	+ .24	− .02
July 22	4770	41	19	.00	+ .14
Sept. 20	4830	82	23	+ .04	+ .18
Nov. 19	4890	41	20	− .01	+ .06
1845 Jan. 18	4950	43	16	− .13	− .12
Mar. 19	5010	51	13	+ .01	− .20
May 18	5070	46	15	+ .03	− .09
July 17	5130	30	13	− .01	+ .09
Sept. 15	5190	76	26	+ .63	+ .20
Nov. 14	5250	69	20	+ .42	+ .12
1846 Jan. 13	5310	23	11	+ .29	− .06
Mar. 14	5370	26	14	+ .14	− .18
May 13	5430	62	16	− .18	− .13
July 12	5490	66	19	+ .17	+ .02
Sept. 10	5550	77	19	+ .07	+ .15
Nov. 9	5610	51	17	+ .37	+ .14
1847 Jan. 8	5670	54	16	+ .36	.00
Mar. 9	5730	65	19	+ .03	− .12
May 8	5790	46	13	+ .10	− .12
July 7	5850	38	14	+ .17	− .01
Sept. 5	5910	–	–	–	+ .09
Nov. 4	5970	6	4	+ .55	+ .10
1848 Jan. 3	6030	19	9	+ .33	+ .01
Mar. 3	6090	38	12	− .14	− .08
May 2	6150	68	12	.00	− .07
July 1	6210	46	13	+ .21	− .20
Aug. 30	6270	53	15	− .22	− .14
Oct. 29	6330	49	8	− .13	− .16
Dec. 28	6390	31	12	− .60	− .24
1849 Feb. 26	6450	36	9	− .59	− .30
Apr. 27	6510	26	5	− .36	− .25
June 26	6570	9	4	− .03	− .15
Aug. 25	6630	–	–	–	− .10
Oct. 24	6690	2	2	+ .06	− .16
Dec. 23	6750	–	–	–	− .28
1850 Feb. 21	6810	–	–	–	− .35
Apr. 22	6870	–	–	–	− .28
June 21	6930	35	11	− .20	− .14
Aug. 20	6990	49	12	+ .07	− .05
Oct. 19	7050	15	8	− .12	− .11
Dec. 18	= 2397110	7	4	−0.42	−0.27

To find the constants of the latitude-variation, we form equations of condition according to the formula on p. 19 (*A.J.* 315), computing the coefficients with $T'_0 = 2393773$, $\theta = 0^\circ.84$; giving weights equal to one-tenth the numbers of observations; and putting for n the observed values of $\varphi-\varphi_0$ in the fifth column of the table. For compactness the normal equations are stated in tabular form below; where $a = 1$, $b = \sin\odot$, $c = \cos\odot$, $d = \sin\gamma$, $e = \cos\gamma$; and the limits of the respective groups are

I 1836.0 – 1839.0; 2391650 – 2392730
II 1839.1 – 1843.4; 2392790 – 2394350
III 1843.5 – 1848.4; 2394410 – 2396150
IV 1848.5 – 1851.0; 2396210 – 2397110

NORMAL EQUATIONS IN TABULAR FORM.

	[*paa*]	[*pab*]	[*pac*]	[*pad*]	[*pae*]	[*pan*]	[*pbb*]	[*pbc*]	[*pbd*]	[*pbe*]	[*pbn*]
I	+ 96	+ 2.46	−11.81	+12.10	−22.33	+ 9.02	+47.80	+ 5.71	+29.14	− 2.14	+ 0.80
II	+ 147	+ 3.82	− 2.94	− 2.82	+ 3.66	−14.54	+73.35	+ 1.17	−31.95	− 0.90	− 2.41
III	+ 156	+ 8.77	− 6.47	+ 0.59	−15.05	+17.58	+68.09	+ 4.13	+ 8.22	+22.68	− 1.51
IV	+ 36	+ 5.19	− 9.99	− 3.77	− 1.88	− 6.32	+18.51	− 2.53	− 4.23	−13.13	+ 3.22

	[*pcc*]	[*pcd*]	[*pce*]	[*pcn*]	[*pdd*]	[*pde*]	[*pdn*]	[*pee*]	[*pen*]	[*pnn*]
I	+48.20	+13.45	+33.50	− 4.07	+45.73	+ 2.40	+ 3.09	+50.27	− 6.88	+2.66
II	+73.65	− 3.81	−36.55	− 9.84	+74.29	+ 3.01	+ 2.46	+72.71	+ 8.05	+5.54
III	+87.91	−20.46	+23.65	−14.77	+69.41	+ 2.25	+ 8.95	+86.59	−10.61	+9.27
IV	+17.49	+12.53	− 1.85	− 1.87	+18.54	− 1.92	− 3.80	+17.46	− 2.38	+3.60

Eliminating x_0 from each of the four groups, and adding the elimination-equations (I+II and III+IV) the solution gives the other unknowns and their probable errors,

	1836.0–1843.4	1843.5–1851.0
y	$+0''.0437 \pm 0''.0203$	$+0''.0333 \pm 0''.0303$
z	$+\ .0223 \pm\ .0203$	$-\ .0861 \pm\ .0286$
η	$-\ .0038 \pm\ .0200$	$+\ .0342 \pm\ .0307$
ζ	-0.1115 ± 0.0201	-0.1534 ± 0.0285

whence by (30) and (25) we have for $\varphi-\varphi_0$:

$$\begin{array}{lllll} 1836.0\text{–}1843.4 & -0''.049 \cos(t-2393633.7)\,0^\circ.84 & & -0''.112 \cos(\odot-362^\circ.0) & \\ & \pm0.020 & \pm28.1 & \pm0.020 & \pm10.3 \\ 1843.5\text{–}1851.0 & -0''.092 \cos(t-2393747.8)\,0^\circ.84 & & -0''.157 \cos(\odot-347^\circ.4) & \\ & \pm0.024 & \pm16.8 & \pm0.029 & \pm10.8 \end{array}$$

The solution for the whole series gives,

$$y = +0''.0461 \pm 0''.0199, \quad z = -0''.0376 \pm 0''.0193, \quad \eta = +0''.0113 \pm 0''.0199, \quad \zeta = -0''.1380 \pm 0''.0192$$

$$\text{whence,} \quad \varphi-\varphi_0 = \underset{\pm0.019}{-0''.060} \cos(t-\underset{\pm30.4}{2393712.5})\,0^\circ.84 \quad \underset{\pm0.019}{-0''.138} \cos(\odot-\underset{\pm7.8}{355^\circ.3}) \tag{50}$$

which is adopted as the definitive expression of the latitude-variation from the Mural Circle observations from 1836 to 1851.

If we substitute these last values of y, z, η, ζ in the normal equations in x_0, for groups I, II+III, and IV, we find

1836.0–1839.0, $x_0 = +0''.062$
1839.1–1848.4, $+0.004$
1848.5–1851.0, -0.213

the addition of which to the values computed from eq. (50) gives the computed values in the last column of the foregoing table.

If we compare the epoch T_1 in eq. (50) with that of eq. (49) in *A.J.* 315, we have the value of the period 422d.7 ± 1d.9. The mean value which satisfies the observations over an interval of nearly one hundred and seventy years is 428d.6 ± 0d.2. The difference of these values is about three times its probable error. Taken by itself this fact would perhaps not be sufficient to demonstrate an actual departure from the mean value of the period. But it appears to be corroborated by the Pulkowa observations, 1840–44. There is similar reason for presumption that the amplitude of this term of the variation suffered material diminution near 1840.

Corresponding variations are perceptible in the constants of the annual term. I think these variations are real, and that the observations are sufficient to give an indication of the law which governs them. I cannot follow the subject further here; its systematic examination has been undertaken, and the results will soon be printed.

Cambridge, 1894 *June* 3.

OBSERVATIONS OF VARIABLE STARS,

By S. D. TOWNLEY.

[Communicated by the Director of the Detroit Observatory.]

The following observations of variable stars were made with the 12¼-inch equatorial telescope of the Detroit Observatory of the University of Michigan. On account of electric lights in the neighborhood of the Observatory it is not possible to observe as faint stars as one would expect with a telescope of this size. Both the method by steps, and that by proportions of interval, have been used.

For the comparison-stars I have adopted the magnitudes determined by me at the Washburn Observatory, and an explanation of the notation employed, and the magnitudes of the comparison-stars, may be found in the Publications of the Washburn Observatory, Vol. VI, Part 3.

From the curves of the plotted observations the following phases have been determined.

The first three figures, 241. of the Julian date are omitted. The column O—C is derived from comparison of the observed phase with the elements as given in CHANDLER'S Second Catalogue of Variable Stars (*Astr. Jour.*, no. 300).

RESULTS OF OBSERVATIONS.

No.	Star	Phase	Mag.	Date		*E*	O—C	Remarks
				Julian	Calendar			
1222	*R Persei*	Max.	8.0	2801	1893 Dec. 3	56	— 3	
1577	*R Tauri*	Min.	12.4	2799	1893 Dec. 1	35	—23	A theoretical light-curve would place min. 5 or 10 d. later
1582	*S Tauri*	Max.	9.3	2839	1894 Jan. 10	33	— 8	Yendell observed this maximum. See *A.J.* no. 315
1717	*V Tauri*	Max.	8.0	2873	1894 Feb. 13	46	—16	" " " " " " "
1761	*R Orionis*	Min.	11.2	2883	1894 Feb. 23	37	— 9	Uncertain, on account of the small number of obsns.

INDIVIDUAL OBSERVATIONS.

Date	Observation	Resulting Mag.
	243. *U Cassiopeae.*	
1892 Aug. 3	(v). (l). k faint	$<13\overset{\mathrm{M}}{.}3$ (*f*)
1893 Dec. 20.4	v and f vis. by glimpses	11.3 :(*a*)
1894 Jan. 12.4	(v). f and g plain	<12.2
Feb. 22.3	(v), f and g plain	<12.2
28.3	(v), f and g plain	<12.2
Mar. 8.3	(v), f and g plain	<12.2 (*b*)
	1222. *R Persei.*	
1893 Nov. 6.3	e 2 v 2 f	9.3
13.5	b 3 v 2 d 3 e 1 f	8.7
25.2	a 7 v 3 b	8.1 (*a*)(*e*)
Dec. 3 2	a 7 v 2 b	8.2
20.2	a 8 v 2 b	8.2 (*a*)
1894 Jan. 12.3	l 4 v 1 e 1 f	9.2
24.3	f 4 v 1 g 2 h 2 k	9.9 (*e*)
Feb. 1.4	g k 2 v	10.5
22.3	k 7 l	11.3
28.4	v l	11.7
Mar. 8.4	l 2 v	11.9 (*d*)
11.4	v l	11.7 (*d*)
29.3	l–v	12 (*b*) (*d*)
Apr. 8.3	l 3–4 v	12.0
	1577. *R Tauri.*	
1893 Nov. 5.4	e 10 v 10 f	11.7
6.4	e 10 v 10 f	11.7
13.4	e 7 f	12.1
Dec. 3.4	e 8 f, v 3 f	12.3 (*b*)
	1577. *R Tauri.* — Cont.	
1894 Jan. 12.2	d 3 f, e 7 v	$11\overset{\mathrm{M}}{.}3$
24.3	d 2 e 3 v	11.0 (*e*)
Feb. 1.3	d e 2 v	10.9
22.3	v 3 e 1 d	10.3 (*e*) (*d*)
28.4	e 5 d	10.2
Mar. 8.4	e 3 d, e 3 v	10.2 (*b*)
11.4	e 1 d, e 1 v	10.1
	1582. *S Tauri.*	
1893 Nov. 6.4	(v). h very faint	<13
7.4	(v)	<13
13.4	h 5-6 v	13.5
Dec. 3.4	e 2 f 4 v 5 h	12.4 (*b*) (*d*)
20.3	b 2 c 3 v 4 d	9.8 (*a*)
1894 Jan. 12.3	a 8 v 1 b 1 c	9.3
24.3	v b e	9.4
Feb. 1.3	b 1 c v	9.5
22.3	v 3 d, c 7 d	9.9
28.4	v 3 d, c 7 d, b 8 d	10.0
Mar. 8.4	d 1 v	10.3
11.4	d 2 v, d 2 e	10.4
	1717. *V Tauri.*	
1893 Nov. 7.5	v 2 e 5 f	11.0
13.5	e 1 v 5 f	11.2
Dec. 3.4	b 8 v 1 e	10.6 (*b*) (*d*)
20.4	v 3 e, b 8 e	10.6

Date	Observation	Resulting Mag.
	1717. *V Tauri.* — Cont.	
1894 Jan. 12.3	a 4 v 2 b d 1 c	$9^{\mathrm{M}}.0$
24.3	v 2 a	8.4
Feb. 1.3	v 4 a 5 b	8.2
22.3	v 1 a	8.5 (*e*)
28.4	v 3 a 7 c	8.3
Mar. 8.4	v a 5 d	8.6
11.4	a 1 v 3 d	8.8
29.4	d 5 v, d 4 e, b 5 e	9.9
Apr. 8.4	e 2 v, e 1 f	11.1
	1761. *R Orionis.*	
1894 Jan. 12.4	e 3 d, e 2–3 v	10.6
Feb. 1.4	e 7 d, v 3 d	11.1
	1761. *R Orionis.* — Cont.	
1894 Feb. 22.3	e 8 d, v 3 d	$11^{\mathrm{M}}.2$
28.4	e 9 d, v 2 d	11.3
Mar. 11.4	e 7 d, v 3–4 d	11.1
	7045. *R Cygni.*	
1893 Nov. 5.4	e d 2 v 3 e	11.1
13.4	d 2 v 2 e	11.1
25.2	e 3 v 3 d	11.0
Dec. 20.3	(v), e very faint	<11.3 (*a*)
1894 Jan. 12.3	(v), e faint	<11.3
Feb. 1.3	(v), f vis. by glimpses	<13.0

NOTES. — (*a*) nearly full moon ; (*b*) hazy, or clouds; (*c*) seeing poor : (*d*) uncertain ; (*e*) difficult on account of contrast of color ; (*f*) with 12-inch equatorial of Lick Observatory ; (*g*) insufficient number of observations.

Ann Arbor, Michigan, 1894 *May* 21.

MAXIMA AND MINIMA OF LONG-PERIOD VARIABLES,

BY J. A. PARKHURST.

906. *R Trianguli.*

Twenty-nine observations were made, from 1893 Oct. 9 to 1894 Mar. 31. The light-curve was rather flat near the minimum, but that phase was fairly well indicated for 1894 Jan. 26, at 11$^{\mathrm{M}}$.7. The rise was more rapid than the decline.

1574. *W Tauri.*

My watch on this star began 1893 Nov. 20, when it was about the 10$^{\mathrm{M}}$. From that time the rise was slow, and somewhat irregular. The maximum, 8$^{\mathrm{M}}$.5, was passed about 1894 Feb. 16. It then fell more rapidly, and when last seen, April 21, it was 11$^{\mathrm{M}}$. I have nineteen observations.

1981. *S Camelopardalis.*

This star passed a minimum 1893 Oct. 28, at 10$^{\mathrm{M}}$.3. The rise was then gradual to the maximum mentioned by Mr. YENDELL in February. Since that time it has fluctuated between 8$^{\mathrm{M}}$.0 and 8$^{\mathrm{M}}$.7. I have thirty-three observations since 1893 Aug. 1; but more are needed to determine the character of the maximum phase.

2100. *U Orionis.*

I have twenty-three observations of this star, from 1893 Dec. 28 to 1894 May 6. During that time it rose rapidly from 10$^{\mathrm{M}}$.5 to a maximum of about 6$^{\mathrm{M}}$.5, 1894 Feb. 22, then fell more slowly to 9$^{\mathrm{M}}$ at the last observation.

2815. *U Geminorum.*

This star passed a short maximum in March 1894. On the 16th it was looked for without success by Mr. W. DEARDEN of Trinidad, Colo., though he saw the comparison-star *l* (Baxendell, 13$^{\mathrm{M}}$.7). I have the following observations, magnitudes on BAXENDELL's scale :

Gr. M.T.	
1894 Mar. 17.5	$9^{\mathrm{M}}.7$
21.5	10.5
23.5	12.0
26.5	13.6

A maximum is thus indicated near Mar. 18.5.

5157. *S Bootis.*

Twenty-eight observations, from 1893 Oct. 7 to 1894 May 6, give a well-marked minimum, 12$^{\mathrm{M}}$.4, 1894 Jan. 19.

5190. *R Camelopardalis.*

A continuous watch has been kept on this star for a year. Twenty-five observations since the last minimum yield a maximum of 7$^{\mathrm{M}}$.7, 1894 Jan. 13.

5338. *V Bootis.*

Since the minimum, 1893 Dec. 12, reported in no. 313, this star rose rapidly till the middle of January, then more slowly, passing a maximum about 10$^{\mathrm{M}}$, 1894 Mar. 21. Since then the decline has been slow, reaching 11$^{\mathrm{M}}$ at the last observation, May 6. I observed the star twenty-six times between the dates mentioned.

5675. *V Coronae.*

A minimum, 12$^{\mathrm{M}}$, is indicated on 1894 Jan. 11 by thirty-four observations between 1893 Sept. 12 and 1894 May 6. The curve is quite flat at this phase, and the minimum may have occurred ten days earlier.

7779. *S Cephei.*

I have observed this star twenty-eight times, from 1893 Sept. 26 to 1894 May 7. A minimum of $12^M.3$ is indicated for 1893 Dec. 24, with an uncertainty of perhaps twenty days, on account of the flatness of the curve and the redness of the star.

DM. 58°2560 (*Cassiopeae*).*

$\alpha = 23^h\ 5^m\ 27^s \qquad \delta = +58°\ 53'.8 \quad (1855).$

I have twenty-one observations of this new ANDERSON variable, from 1894 Jan. 18 to May 7. When first seen it was $>10^M$. It fell steadily, passing a minimum about 12^M, 1894 Mar. 21, then rose more rapidly till when last observed it was again 10^M. At minimum it was near the limit of vision of my 6.2-inch reflector, at a low altitude. The light curve is regular.

8600. *R Cassiopeae.*

Thirty-two observations, from 1893 July 3 to 1894 April 5, yield a minimum 12^M, 1894 Jan. 28. The star was poorly placed for an accurate determination of the minimum.

Except where otherwise stated, the magnitudes are on the historic scale.

Marengo, Ill., 1894 *May* 9.

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*8324 *V Cassiopeae.* Disc. by ANDERSON; conf. by HARTWIG.

PRELIMINARY NOTE ON THE RE-APPEARANCE OF COMET 1889 V,

By CHARLES LANE POOR.

Making BAUSCHINGER's elements, as given in my article in *Astronomical Journal*, no. 302, the basis of the work, I carried the elements forward to the time of perihelion passage in 1896. During the entire interval, between 1889 and 1897, the perturbations of *Jupiter*, *Saturn* and the *Earth*, were taken into account; those due to *Mars* were considered for a short period only. The intervals of computation were twenty days during 1889 and 1890, forty days during 1891–1894 inclusive, and again twenty days during 1895 and 1896. The resulting elements for the next appearance of this comet are as follows:

Epoch 1896 October 22.5 Greenw. M.T.

$$\left.\begin{array}{rcrrr} & & ° & ' & '' \\ \pi & = & 1 & 48 & 42.42 \\ \Omega & = & 18 & 1 & 7.70 \\ i & = & 6 & 3 & 33.66 \\ \omega & = & 343 & 47 & 34.72 \end{array}\right\}\ 1896.0$$

$$\begin{array}{rcl} \log a & = & 0.567\,3406 \\ \log e & = & 9.671\,5748 \\ \log \mu & = & 2.698\,9957 \\ T & = & \text{1896 November 3.9382 Gr. M.T.} \end{array}$$

The comet should be seen in the middle of May, 1895, when its theoretical brightness will be 0.06, that at the time of discovery being taken as unity. That is, during next May and June, the comet will be a trifle fainter than when last seen at the Lick Observatory in January, 1891. Only the largest glasses will be available, but it is most important that observations should be secured if possible. If the comet be not found next spring, then it cannot be seen until in February or March of 1896.

I have lately revised and extended the tables of the approach to *Jupiter* in 1886, which appeared in *Astronomical Journal*, no. 303, and hope that observations next spring will finally set at rest the question as to the identity of this comet with that of Lexell. Whatever be the conclusions then reached, I expect to make finally a definitive discussion of the two appearances of this remarkable body, and to determine as accurately as possible all the circumstances of the appulse to *Jupiter*.

I have had computed a complete ephemeris of the comet for the possible times of visibility in the years 1895 and 1896, and will send a copy to any one who may be interested in the matter.

OBSERVATIONS OF COMET *b* 1894 (GALE) AND OF ASTEROID (103) *HERA*,

MADE AT THE DUDLEY OBSERVATORY, ALBANY, N.Y.,

BY LEWIS BOSS.

1894 Albany M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			COMET *b* 1894 (GALE).					
May 27 $9^h\ 10^m\ 57^s$	4	18 , 9	$-0^m\ 33^s.83$	$+5'\ 16''.2$	$10^h\ 48^m\ 24^s.79$	$+36°\ 48'\ 31''.1$	9.554	0.265
29 9 38 13	5	15 , 5	+3 53.32	+3 27.6	10 54 57.86	+37 48 1.2	9.614	0.314
			ASTEROID (103) *Hera.*					
May 29 14 12 32	1	10 , 4	+0 20.88	−2 20.7	18 52 51.95	−16 49 17.2	n8.260	0.880

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	18 52 28.63	+2.41	−16 46 43.6	−12.9	W. Argel. 14891; Munich 18150
4	10 48 56.93	+1.69	+36 43 14.9	+ 5.5	Lund A.G. Zones, 168, 192
5	10 51 2.86	+1.68	+37 41 27.7	+ 5.9	Lund A.G. Zones, 174, 176

OBSERVATIONS OF COMET *b* 1894,

MADE AT THE U.S. NAVAL OBSERVATORY, WITH THE 9.6-INCH EQUATORIAL,

BY PROF. E. FRISBY AND ASSISTANT ASTRONOMER G. A. HILL.

(Communicated by the Superintendent.)

1894 Washington M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log *p*Δ for α	log *p*Δ for δ	Obs.
h m s			m s	′ ″	h m s	° ′ ″			
April 29 8 20 9.1	1	15 , 3	+3 1.54	− 6 30.8	7 30 29.13	−22 48 11.6	9.585	0.832	H.
30 8 11 16.7	2	20 , 4	−1 33.26	− 0 59.0					H.
May 1 8 11 54.0	3	20 , 4	−1 6.98	− 1 49.7	7 56 4.52	−14 37 19.0	9.518	0.820	F.
3 8 9 50.8	4	20 , 4	+1 2.64	+ 4 25.2	8 19 25.91	− 6 26 26.2	9.469	0.784	F.
4 9 3 20.8	5	15 , 3	+1 20.07	− 0 44.4	8 30 38.02	− 2 24 6.4	9.436	0.760	H.
9 28 46.9	6	20 , 4	+0 37.09	+ 1 34.6	8 30 48.60	− 2 18 43.2	9.589	0.754	F.
7 9 20 50.9	7	20 , 4	−3 38.99	+10 29.1	8 59 44.82	+ 8 7 0.9	9.558	0.687	F.
9 8 25 18.5	8	20 , 4	+0 35.59	+11 37.5	9 16 7.84	+13 45 28.3	9.561	0.637	F.
12 10 0 39.4	9	20 , 4	+0 53.32	+ 6 10.6	9 38 20.90	+20 46 53.1	9.612	0.581	H.
10 2 25.7	9	20 , 4	+0 53.64	+ 6 17.0	9 38 21.22	+20 46 59.5	9.612	0.581	F.
13 9 3 54.0	10	20 , 4	+1 40.51	+ 3 5.6	9 44 33.81	+22 35 21.4	9.520	0.494	H.
20 10 16 0.0	11	5 , 1	−4 48.26	− 6 13.2	10 21 45.01	+31 50 59.2	9.160	0.853	H.
27 10 30 17.8	12	23 , 5	−0 20.56	+ 7 15.7	10 48 38.05	+36 50 30.7	9.701	0.384	F.
28 11 10 1.0	13	20 , 4	+3 2.71	+ 1 1.6	10 51 52.64	+37 20 34.9	9.703	0.318	F.

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	7 27 27.54	+0.05	−22 41 34.8	−6.0	Weisse-Argel. 5669
2					D.M. 18°2040
3	7 57 11.21	+0.29	−14 35 24.1	−5.2	Weisse-Bessel VII, 1636
4	8 18 22.81	+0.46	− 6 30 47.9	−3.5	$\frac{1}{4}$(Weisse-Bessel +3 Munich)
5	8 29 17.39	+0.56	− 2 23 19.4	−2.6	Weisse-Bessel 704
6	8 30 10.94	+0.57	− 2 20 15.2	−2.6	$\frac{1}{3}$(Weisse-Bessel +2 Schjell.)
7	9 3 22.96	+0.85	+ 7 56 32.3	−0.5	$\frac{1}{5}$(Weisse-Bessel +2 Paris +2 Grant)
8	9 15 31.27	+0.98	+13 33 49.8	+1.0	$\frac{1}{3}$(Weisse-Bessel +2 Grant)
9	9 37 26.40	+1.18	+20 40 39.8	+2.7	$\frac{1}{8}$(Weisse-Bessel +3 Grant +4 Yarn.)
10	9 42 52.08	+1.22	+22 32 12.6	+3.2	Weisse-Bessel (2) 857, 8
11	10 26 31.73	+1.54	+31 57 8.1	+4.3	Leyden A.G.Z. 172, 175
12	10 48 56.92	+1.69	+36 43 9.4	+5.6	Lund A.G.Z. 188, 192
13	10 48 48.25	+1.68	+37 19 27.5	+5.8	Lund A.G.Z. 1, 163, 174, 176

CORRIGENDUM.

No. 317, p. 38, Observation of Comet *a*, May 2, Albany M.T., *for* 11h 14m 44s *put* 10h 54m 47s.

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OBSERVATIONS OF SUSPECTED VARIABLES,

By PAUL S. YENDELL.

(5) — *Ceti.*

This star has been announced from the Tacubaya Observatory as probably variable. I have only three observations, which are not decisive, though their regular progression is very suggestive of actual decrease. The observations are as follows:

			M
1893	Oct.	31,	8.5
	Nov.	10,	8.8
		30,	9.1

DM. +1° 3417.

R.A. = $17^h\ 12^m\ 11^s.7$. Decl. = +1° 40′.3. (1855)

I have five observations of this star, as follows:

			M
1894	Apr.	29,	7.6
	May	7,	7.7
		9,	8.0
		12,	7.6
		22,	7.6

The magnitudes are estimated from the DM. magnitudes of the stars used as comparison-stars, the star having been >DM. +1° 3422, $7^M.8$ and < +1° 3421, $7^M.2$, on four of the five dates on which it was observed.

(691) — *Persei.*

Since the observations in search of this star, published in this Journal, Vol. XIII, p. 175, I have looked for it on the following dates:

			M
1893	Nov.	30,	<12
1894	Jan.	8,	<12
	Feb.	5,	<11
		11,	<11

During the twenty-seven months, from 1891 Nov. 30, to 1894 Feb. 11, I have looked in vain for this star, twenty-eight times; have examined and re-examined the original announcement, my chart, and the position given for the star; and am forced to the conclusion, that there is some error in the announced position, or that some erroneous identification has been made by the observers who consider that they have seen it.

(1279) — *Camelopardalis.*

Since the observations published in this Journal, Vol. XIII, p. 175, I have observed this star seven times; the result of these observations has been to raise a doubt of the star's constancy, which I had considered to be fully proved by my observations, up to the date of the paper referred to.

The estimates of magnitude given up to this time have been made by simple comparison of the step-differences with the Bonn magnitudes of the comparison-stars. Since obtaining the more recent observations, however, I have re-estimated them from a careful graphic comparison of these magnitudes with the light-scale; the resulting magnitudes are as follows:

			M				M
1891	Dec.	3,	8.43	1893	Sept.	16,	8.60
		5,	8.50		Oct.	9,	8.40
		28,	8.60			14,	8.30
1892	Jan.	16,	8.60			18,	8.30
	Mar.	5,	8.20		Nov.	1,	8.40
		29,	7.60			8,	8.30
	Apr.	19,	7.60	1894	Jan.	8,	8.50
	Oct.	19,	8.50			28,	8.40
		22,	8.40		Feb.	2,	8.40
	Oct.	29,	8.40		Mar.	6,	8.50
	Dec.	16,	8.50			24,	8.70
1893	Apr.	4,	8.30		Apr.	5,	9.20
	Sept	13,	8.40			25,	8.90

There seems to be much disagreement as to the probable variability of this star. The well-known difficulty of observing stars so extremely red as this, and the discrepancies between the simultaneous observations of practised observers, which have recently come to my notice in a precisely similar case, lead me to be very cautious in passing judgement in the present instance. The two groups of observations in the spring of 1892 and 1894, depart only $0^M.8$ from the general mean of the rest of the observations, which is less than the differences of estimation at several simultaneous dates, in the instance above referred to; and, though HARTWIG (*V.J.S. Ephemeris*, for 1894, p. 297), says that the star “ is in fact variable, is now (Nov.,

1893) slowly increasing from 8^M since Nov., 1892, and will soon pass a maximum of 7^M.” a glance at the above list of estimates will show that, according to my observations, the star had, in all probability, been absolutely constant during the entire time covered by the remarks above quoted.

DM. 56°724.

R.A. = $2^h\ 39^m\ 58^s.3$ Decl. = +56° 22′.6. (1855)

This star has been announced as variable by Espin, on the evidence of photographs made with the Compton telescope.

I have twenty-eight observations of it, from 1893 Dec. 28, to 1894 May 3, which show a decrease from $8^M.9$ to $9^M.8$; the decrease has been regular and steady, and I have no doubt of the star's variability.

R.A. = $2^h\ 6^m\ 36^s$. Decl. = +57° 50′. (1855.0)

The variability of this star was announced by Hartwig (*Astr. Nachr.* 3203). My observations favor the star's variability, but in consideration of the rather conflicting evidence in the case, they are not certainly decisive. From 1894 Jan. 10, to Apr. 25, twenty-one observations indicate a slow and fluctuating decrease, from $9^M.3$ to about 10^M.

Mr. J. A. Parkhurst, in a private letter, informs me that the star appears at times very red. It is too faint in my telescope for any color to be distinguishable; but, in view of the known influence of redness on light-estimates, alluded to above, in the case of (1279), I hesitate to pronounce upon the actuality of the change indicated.

(5076) — *Bootis.*

I have observations of this star, very accordant, as follows:

			M
1893	Aug.	22,	9.2
		29,	9.2
	Sept.	2,	9.2
1894	Mar	7,	9.0
		24,	9.0
1894	Mar.	26,	9.0
	Apr.	25,	8.9
	May	1,	8.9
		8,	9.0
		22,	9.0

These estimates are from the DM. magnitudes of the comparison-stars, and may be out by one or two-tenths of a magnitude; but in any case, afford no evidence of variation during the time the star has been watched.

(7205) — *Cygni.*

I have five observations during the autumn of 1893, showing an apparent change from $8^M.8$ to $9^M.2$, between Oct. 15 and Dec. 2. These seem to favor the star's variability, but are not decisive. The observations are as follows:

			M
1893	Oct.	15,	8.8
		21,	8.8
	Nov.	1,	8.8
		26,	9.1
	Dec.	2,	9.2

(7238) — *Cygni.*

Espin considers this star to be variable. Seven observations, from 1893 May 18 to Sept. 16, give no evidence of actual change; they are as follows:

			M
1893	May	18,	10.
	June	1,*	
		10,	10.5
	July	4,	<10.5
		14,	10.
		23,	10.5
	Sept.	16,	10.5

Dorchester, 1894 *May* 25.

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* Not seen ; limit 11^M ±; identification uncertain.

ON A UNIFORM SYSTEM OF CLOCK-STARS.

By A. Hall.

Whatever may be the outcome of the interesting propositions of Dr. Gill in the Monthly Notices, April, 1894, for the advancement of astronomy of precision, and whether the ends proposed shall be reached by a congress of astronomers, or by discussion in the journals, there is one fundamental step that it would seem easy to take. We have now four great astronomical ephemerides, the *Connaissance des Temps*, the English Nautical Almanac, the *Berliner Jahrbuch*, and the American Ephemeris. Each of these works has its own list of clock-stars, and the positions of the planets will be reduced with one or the other of these lists. Taking at random the positions of twenty of the bright stars from these lists, we find differences amounting in some cases to a second of arc, and frequently to half a second, although these stars have been observed nearly one hundred and fifty years. Such differences will appear of course in the observed positions of the planets. But why cannot the Superintendents of these ephemerides consult together and agree on a common system of clock-stars? Even if such a system be not the best possible, it would, as was pointed out by Bessel long ago, introduce order and harmony into the observations, and render them more easy of reduction.

1894 *June* 2.

ELEMENTS AND EPHEMERIS OF (103) *HERA*,

BY LEWIS BOSS.

The programme for the Dudley Observatory this year includes observations of a small number of asteroids, of which *Hera* is one. Mr. JOHN H. OGBURN, junior assistant, has, accordingly, prepared an ephemeris for our use. It was found that Mr. LEVEAU's elements of this planet (*B. J.* for 1896), without taking account of perturbations from the epoch to the present time, would well represent an observation made here, May 29, if the value of *M* be corrected by $-44''.3$. The elements thus corrected and for equinox 1894.0 are

Epoch 1895 Jan. 10.0 Berlin M.T.

$$\begin{aligned} M &= 4^\circ\ 55'\ 38''.9 \\ \left.\begin{aligned} \omega &= 185\ \ 33\ \ \ 9.7 \\ \Omega &= 136\ \ 13\ \ 26.7 \\ i &= 5\ \ 24\ \ 38.1 \end{aligned}\right\} &\ 1894.0 \\ \varphi &= 4\ \ 33\ \ 49.1 \\ \mu &= 798''.9097 \end{aligned}$$

The magnitude at opposition is 9.8.

EPHEMERIS OF (103) *Hera* FOR BERLIN MIDNIGHT.

1894	App. α h m s	App. δ ° ′	log *r*	log Δ
May 26	18 53 1	−16 48.9	0.4082	0.2201
June 2	18 51 2	16 51.3	.4077	.2123
6	18 48 40	16 55.0	.4073	.2052
10	18 45 57	16 59.8	.4069	.1990
14	18 42 56	17 5.9	.4064	.1937
18	18 39 39	17 13.0	.4060	.1895
22	18 36 11	17 21.2	.4056	.1864
26	18 32 36	17 30.2	.4052	.1844
30	18 28 57	17 40.1	.4048	.1837
July 4	18 25 19	17 50.6	.4044	.1841
8	18 21 46	18 1.7	.4040	.1856
12	18 18 23	18 13.3	.4036	.1884
16	18 15 15	18 25.2	.4033	.1922
20	18 12 24	18 37.3	.4029	.1971
24	18 9 53	18 49.7	.4025	.2028
28	18 7 44	19 2.2	.4022	.2094
Aug. 1	18 6 1	19 14.7	.4018	.2168
5	18 4 44	19 27.2	.4015	.2248
9	18 3 55	19 39.6	.4012	.2333
13	18 3 34	19 51.8	.4009	.2423
17	18 3 41	−20 3.8	0.4006	0.2517

ON THE LIGHT-VARIATIONS OF 7149 *S SAGITTAE*,

BY PAUL S. YENDELL.

The variability of this star was detected by GORE, in 1885, and announced by him in the Monthly Notices of the Royal Astronomical Society, Vol. 46, p. 106; observations upon it were at once taken up by CHANDLER, SAWYER, REED, and its discoverer, and in 1888 by myself, so that the star has been pretty constantly under observation since its variability was discovered.

CHANDLER (*Astr. Nachr.*, Vol. 115, p. 217), published, in 1886, a preliminary discussion of the data then available, and gave elements and a provisional sketch for a mean light-curve: he was followed by REED and SAWYER (*Astr. Jour.*, VII, pp. 85 and 182), who gave corrections to the first elements, and the latter a provisional light-curve; the maxima and minima deduced from my own observations have also been published in this Journal, VIII, p. 146, and at various times since.

Mr. GORE has also published his observations in the Monthly Notices of the Royal Astr. Soc. at various times.

During my early observations of the star, I received an impression that the maximum phase was not always so sharply marked as indicated by the preliminary curves published by Messrs. CHANDLER and SAWYER; its light appeared to remain nearly stationary at maximum for sometimes as long as three days; and some maxima were difficult to determine by the single light-curve method, on account of apparent fluctuations at this phase. Vexatious and discouraging residuals of about a day, with pretty equal distribution of signs, were also apt to result from reduction by this method, as will be seen by examining the table of observed maxima given below. An experimental light-curve, made in 1889, the normals for which are made up from half-day groups, indicates a slight depression at the computed time of maximum.

At the end of the season of 1893, my observations had accumulated to the number of over four hundred, and I considered that the means were at hand for a more definitive study of the star's light-curve than had previously been made.

I therefore proceeded to form a light-scale from the whole body of the six years' observations.

The comparison-stars used are those given by CHANDLER, in his paper above referred to; they are here recapitulated, with the light-scale, and deduced magnitudes. In the subjoined table, U.N. stands for ARGELANDER's Uranometria Nova; H, for HEIS, and DM. for the Bonn Durchmusterung; Y denotes my own determinations of magnitude from the light-scale.

The value of a single step is $0^{\mathrm{M}}.12^{6}$.

Comparison-Stars.

Star	Name	DM.	U.N.	H	Y	Light
		M	M	M	M	st
a =	F. 14 *Sagittae*	5.0	6.0	6.5	var.?	11.8
b =	11 “	5.8	6.0	6.0	5.84	9.9
c =	13 “	5.8	6.0	6.0	6.08	7.9
d =	DM. 18°4216	6.6	–	6.7	6.66	3.0
e =	DM. 16°4086	7.0	–	–	7.00	0.0

The observations of the season of 1893 indicate, by the use of the single light-curve, eight maxima, which are incorporated in the table of observed maxima, to be hereafter given; and five minima, as follows:

1893 July 14.3	3
23.6	4
30.8	3
Aug. 8.3	3
Sept. 11.3	3

The following table contains the observed dates of maxima and minima which I have been able to collect. In the columns headed “Ob.,” the letter G stands for Gore; H for Harvard College Observatory; E for Espin; O for Oxford; C for Chandler; S for Sawyer; R for Reed; and Y for myself.

From E 500, forward, the maxima marked G are reduced by myself by the use of the single light-curves, from Gore's observations, published at various times in the Monthly Notices; my own maxima, marked *, were obtained by the application of a mean light-curve; the others by the single curves.

The residuals in the columns O—C are from comparison with Chandler's elements.

Observed Maxima, 1876 to 1893.

E	Boston M.T.	O—C	Ob.	E	Boston M.T.	O—C	Ob.	E	Boston M.T.	O—C	Ob.
0	1876 Dec. 14.2	+0.80	G	436	1886 Dec. 17.29	+0.71	R	566	1889 Dec. 9.83*	−0.45	Y
123	1879 Oct. 10.2	−0.34	“	437	26.72	+1.76	“	567	18.26*	−0.41	“
161	1880 Aug. 23.7	0.00	H	500	1888 June 4.4	−0.60	Y	585	1890 May 19.40	+0.83	“
204	1881 Aug. 19.9	+0.32	“	501	13.53*	+0.15	“	588	June 13.88	+1.16	“
260	1882 Dec. 2.2	+0.17	E	502	22.40*	+0.64	“	591	July 7.25	−0.62	“
292	1883 Aug. 27.2	−0.28	O	503	30.17*	+0.02	“	592	16.23	−0.03	“
339	1884 Sept. 24.2	−0.11	G	504	July 8.53	−0.08	“	593	24.62	−0.02	“
387	1885 Oct. 31.53	−0.17	“	505	16.70	−0.21	“	594	Aug. 2.90	+0.88	“
388	Nov. 9.20	+0.12	“	506	24.40	−0.90	“	595	10.60	+0.19	G
389	16.84	−0.63	“	508	Aug. 11.60*	+0.54	“	596	18.14	−0.65	Y
390	25.80	−0.05	“	510	28.45	+0.62	“	598	Sept. 4.40	−0.15	G
391	Dec. 4.57	+0.34	“	511	Sept. 5.33	+0.12	“	“	4.47	−0.08	Y
“	4.20	−0.03	C	514	30.00	−0.36	“	600	21.90	+0.58	G
392	12.92	+0.30	G	515	Oct. 8.62*	−0.12	“	“	22.25	+0.93	Y
“	12.92	+0.30	C	516	18.40	+1.27	“	601	29.80	+0.10	“
393	21.45	+0.45	G	“	16.50	−0.63	G	602	Oct. 8.60	+0.51	G
“	20.84	−0.16	C	517	24.25	−1.26	Y	603	15.87	−0.60	Y
394	29.26	−0.12	G	518	Nov. 2.40	−0.49	“	606	Nov. 12.70	+2.08	G
“	29.75	+0.37	C	519	12.40	+1.12	“	631	1891 June 8.40	+0.20	Y
395	1886 Jan. 6.26	−0.51	“	520	19.25	−0.41	“	634	July 4.50	+1.15	“
411	May 20.60	−0.30	“	521	27.80	−0.24	G	635	11.70	−0.04	“
426	Sept. 23.27	−0.47	S	529	1889 Feb. 2.74*	−0.37	Y	636	21.30	+1.18	“
427	Oct. 1.40	−0.73	“	542	May 21.20*	−1.89	“	637	28.62*	+0.12	“
428	10.30	−0.21	“	543	30.65*	−0.82	“	640	Aug. 24.66	+2.01	“
429	18.81	−0.08	“	544	June 8.72	−0.13	“	642	Sept. 7.60	−0.82	“
“	20.97	+2.08	R	557	Sept. 25.12*	−0.71	“	643	16.70*	−0.10	“
431	Nov. 4.38	−0.28	S	558	Oct. 4.71*	+0.49	“	645	Oct. 2.87*	−0.70	“
“	4.45	−0.21	R	559	13.60*	+1.00	“	647	22.30	+1.97	“
432	12.96	−0.08	S	560	22.80	+1.82	G	649	Nov. 6.70	+0.60	“
“	14.31	+1.27	R	“	21.27*	+0.29	Y	672	1892 May 17.42	+0.50	“
433	20.43	−1.00	S	561	30.50	+1.13	G	674	June 2.89	+0.21	“
434	29.15	−0.66	“	562	Nov. 5.48*	−1.27	Y	675	13.10	+2.03	“
“	29.65	−0.16	R	563	14.98*	−0.15	“	678	July 7.40	+1.18	“
435	Dec. 7.91	−0.28	S	564	24.30	+0.68	G	679	15.50	+0.90	“
“	9.31	+1.12	R	565	30.58*	−1.32	Y	680	24.40	+1.42	“

E	Boston M.T.	O—C	Ob.	E	Boston M.T.	O—C	Ob.	E	Boston M.T.	O—C	Ob.
681	1892 July 31.10	−0.27	Y	690	1892 Oct. 13.02	−1.80	Y	724	1893 July 27.40	+0.56	Y
683	Aug. 18.00	+0.87	"	691	25.63	+2.43	"	725	Aug. 4.60	+0.38	"
684	24.70	−0.81	"	693	Nov. 11.36	+1.40	"	726	11.80	−0.81	"
685	Sept. 2.79	−0.11	"	694	17.30	−0.05	"	729	Sept. 8.30	+1.54	"
686	10.90	−0.38	"	697	Dec. 11.41	−1.09	"	730	14.80	−0.34	"
687	20.20	+0.54	"	716	1893 May 20.90	+0.13	"	734	Oct. 19.50	+0.83	"
688	27.10	−0.95	"	721	July 1.80	+0.11	"				
689	Oct. 6.47	+0.04	"	723	18.50	+0.04	"				

In forming the mean light-curve, the step-values found from the use of the light-scale were arranged in chronological order, using the computed times of maximum according to Chandler's elements as the zero-point, and assembled in groups of ten; the normals obtained from these groups are as follows, the residuals in the column *d* being the departure of the normals, expressed in steps of the light-scale, from the curve as finally drawn.

Table of Normals.

Time	Lt.	w	d	Time	Lt.	w	d
	st.		st.		st.		st.
−3.13	4.92	38	−0.37	+1.05	10.35	32	+0.13
−2.86	6.41	34	+0.74	+1.18	10.33	26	−0.21
−2.70	6.14	39	+0.17	+1.22	10.65	37	+0.04
−2.57	6.82	35	+0.57	+1.56	10.90	37	+0.03
−2.45	7.19	38	+0.68	+1.82	8.73	34	−1.07
−2.29	5.70	37	−1.21	+2.00	8.42	34	−0.62
−2.15	7.02	39	−0.28	+2.25	8.25	38	±0.00
−1.99	7.83	36	+0.05	+2.45	8.85	39	+0.91
−1.84	7.88	29	−0.41	+2.70	7.70	37	+0.13
−1.59	8.95	33	−0.12	+2.88	7.00	39	−0.37
−1.41	9.50	37	−0.18	+3.05	8.47	36	+1.14
−1.28	10.30	35	+0.22	+3.22	6.67	39	−0.20
−1.10	10.47	40	−0.10	+3.37	5.18	37	−1.54
−0.91	10.87	25	+0.01	+3.58	7.30	38	+0.83
−0.73	10.14	35	−0.05	+3.75	6.43	39	+0.17
−0.49	9.83	32	+0.19	+3.90	5.68	39	−0.42
−0.33	8.95	31	−0.46	+4.07	6.50	37	+0.43
−0.17	9.70	28	+0.39	+4.25	5.25	37	−0.51
±0.00	9.13	37	−0.15	+4.40	6.24	38	+0.61
+0.12	9.95	28	+0.65	+4.63	5.55	37	+0.09
+0.36	9.05	35	−0.33	+4.82	5.97	39	+0.63
+0.59	9.75	31	+0.22	+4.96	5.50	36	+0.21
+0.81	9.67	29	−0.19	+5.10	4.84	38	−0.36

The average departure of the curve from the normals is $0^{st}.397$, $= 0^{M}.047$.

These normals indicate a decided, though small, depression of the curve in the computed place of the maximum phase, making a double maximum at an interval of rather more than two days; those near the minimum show some discordance, possibly attributable to the inconvenience of the comparison-stars used for this part of the period; the point of actual minimum is, however, pretty definitely indicated.

As I had for several years suspected the comparison-star *a* of more or less fluctuation, it seemed possible that the apparent depression at maximum might perhaps be due to this cause, in part, at least, although the use of this star had been discontinued since 1889; but upon eliminating the comparisons in which it was used from the normals in which they appeared, the feature was, if anything, a little more marked than when these comparisons were taken into account.

As will be seen upon examining the table of maxima, considerable residuals, with a pretty impartial distribution of sign, are shown by many of them, especially in those determined from the single curves: the use of a mean light-curve, in forming which no account has been taken of this depression, tends to mask these differences; but notwithstanding this, some indications of them appear in the published times of Chandler, Reed, and Sawyer.

The curve indicated by the normals is very peculiar; the minimum occurs at −3.273 days; a sharp rise from minimum is shown, followed by two distinct and equal minima, at −0.93 days and +1.48 days, separated by a depression of about 0.2 mag., the lowest point occurring at the computed time of maximum; the second maximum is followed by a very sudden inflection in the curve, the normals indicating what amounts almost to a third sub-maximum. The curve has nothing in common with the *β Lyrae* type, but is a variation of the ordinary *η Aquilae* type of short-period light-curves, or may perhaps be considered, like the former, as forming a distinct type by itself.

The readings from the curve are as follows:

Reading from Mean Light-Curve.

Time	Light	Time	Light	Time	Light	Time	Light	Time	Light	Time	Light
d	st.	d	st.	d	st.	d	st.	d	st.	d	st.
−3.273	5.20	−1.8	8.36	−0.4	9.46	+1.2	10.58	+2.6	7.70	+4.2	5.80
3.2	5.21	1.6	9.04	−0.2	9.32	1.4	10.86	2.8	7.45	4.4	5.63
3.0	5.44	1.4	9.70	±0.0	9.28	1.48	10.90	3.0	7.20	4.6	5.48
2.8	5.77	1.2	10.34	+0.2	9.32	1.6	10.76	3.2	6.90	4.8	5.35
2.6	6.18	1.0	10.80	0.4	9.39	1.8	9.85	3.4	6.68	+5.0	5.26
2.4	6.62	0.93	10.86	0.6	9.54	2.0	9.04	3.6	6.45		
2.2	7.15	0.8	10.68	0.8	9.84	2.2	8.55	3.8	6.20		
−2.0	7.75	−0.6	9.85	+1.0	10.20	+2.4	8.00	+4.0	6.00		

Dorchester, Mass., 1894 *May* 31.

ON THE FORMS OF THE DISKS OF *JUPITER'S* SATELLITES.

By J. M. SCHAEBERLE.

The contradictory results obtained by different observers of *Jupiter's* satellites seem to indicate that with our present instrumental means it may be impossible to decide definitely the exact form of celestial bodies presenting very small disks. The evidence seems to prove that the unavoidable errors of judgement in different conscientious observers are often due to radically different causes. Just how these different errors are produced is not clear, but that some of the observers are wrong the discordance in the results proves.

The case of *Jupiter's* first satellite furnishes a good example. In a careful series of observations of this body made with the special purpose of determining the form of the disk, Professor Barnard, with one single exception, recorded the satellite as circular in outline on eighteen different occasions.[1] To Professor Campbell and myself the satellite appears round only when it is very near to or projected on the disk of *Jupiter*, and elongated in the direction of the planet's equator in all other positions.[2] Professor Holden states that during our observations he satisfied himself that the disk of *I* was elliptical, and that of *III* round when the satellites were off the disk. Professor W. H. Pickering, on the other hand, observed regular periodic changes of such a nature that the interval of time between a circular phase and the next following (or preceding) maximum elliptical phase was only about six and one-half hours.[3] The last mentioned observations were made at Arequipa, and have not been verified elsewhere.

As an illustration of my own observations of satellite *I*, made near its elongation for the special purpose of detecting a rapid change of phase, the results of a series of measures of the major and minor axes of the several elliptical disks as drawn by me on Dec. 9, 1893, are here given.

Mt. Hamilton P.S.T. of drawing	Ratio of diameters
h m	
8 40	0.84
9 35	0.86
11 25	0.83
12 10	0.80
13 20	0.83
14 20 (note) no drawing	(0.83) same as at 13h 20m

It will be seen that during a continuous interval of 5h 40m my observations gave a practically constant form for the outline; during this time all the other satellites appeared nearly round.

As bearing directly upon the Arequipa satellite-observations a significant fact, apparently showing the great superiority of the Mt. Hamilton results over those obtained by Professor W. H. Pickering, will now be briefly considered.

In a paper[4] published in no. 305 of this Journal I proved that the apparently abnormal forms of the shadows which I repeatedly observed here, and which had at divers times been observed by others, were not abnormal at all, but required by theory. The past literature of this subject reveals the fact that some of the ablest astronomers must at times have regarded the shadows as round when, as the theory will prove, they were very far from being so. So strongly has the heretofore generally received idea — that the shadows as viewed from the earth should always be practically circular — influenced the judgement of observers in general that the comparatively few records describing the true form of the shadow when it was not round have been regarded with more or less doubt, at times, by even the actual observers of the phenomenon.

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[1] Astronomy and Astro-Physics for April, 1894, page 272.

[2] Publication of the Astronomical Society of the Pacific. 1891, Vol. III, page 355.

[3] Astronomy and Astro-Physics for May, 1893, page 390.

[4] A Simple Geometrical Explanation of the Causes of the Observed Distortions of the Shadows of *Jupiter's* Satellites.

Now one would naturally suppose that an observer, after having discovered, as he believed, a periodic variation in the form of a satellite, would seek to verify his results by examinations of the satellite's shadow during its transit across the disk of the planet. Taking the January 1893 observations of the satellites as observed at Arequipa, I find that the longest (longitudinal) diameter of every shadow, just after its ingress on the visible disk of *Jupiter*, was more than twice the breadth of the shadow, while at egress just the reverse condition of things existed. That this enormous distortion escaped the scrutiny of the Arequipa observers seems to be shown by the published evidence, for nowhere, as far as I know, does it appear that the repeatedly distorted shadow-outlines were ever observed at Arequipa. At the Lick Observatory, on the other hand, the systematic recurrences of the various phenomena during the shadow's transit were so persistently observed by myself that they led to the discovery of the true explanation.

Lick Observatory, 1894 *June* 9.

OBSERVATIONS OF PLANETS (349) AND *AX*,

MADE AT THE CINCINNATI OBSERVATORY,

BY PHILLIPS ISHAM.

1894 Cincinnati M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
			Planet (349) (Dembowska).					
	h m s		m s	′ ″	h m s	° ′ ″		
Mar. 9 8 54 20	1	8	+2 3.69	−1 15.4	11 5 27.63	+15 45 44.5	*n*9.528	0.606
9 25 1	2	8	+1 16.89	+3 47.0	11 5 26.58	+15 45 47.5	*n*9.461	0.587
10 8 25 36	1	8	+1 14.03	+1 47.6	11 4 37.97	+15 48 47.5	*n*9.569	0.621
13 9 59 35	3	9	+0 31.36	+5 21.3	11 2 4.15	+15 57 40.4	*n*9.285	0.558
16 7 58 40	4	8	−0 15.08	+2 41.9	10 59 41.42	+16 4 57.1	*n*9.567	0.616
24 7 56 0	5	8	+1 34.38	−0 39.4	10 53 37.82	+16 19 2.5	*n*9.504	0.591
			Planet *AX*.					
Apr. 25 9 59 14	6	8	+0 56.53	+0 57.3	10 30 3.87	+ 5 5 53.2	9.311	0.718
28 9 13 39	7	11	−2 1.70	−8 29.9	10 30 29.52	+ 4 51 7.7	9.149	0.698
May 4 10 22 14	8	10	−1 18.48	+2 52.5	10 32 11.50	+ 4 21 50.1	9.475	0.711

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	11 3 22.07	+1.87	+15 47 7.5	−7.6	Paris 13617
2	11 4 7.82	+1.87	+15 42 8.1	−7.6	Paris 13629
3	11 1 30.88	+1.91	+15 52 26.5	−7.4	Paris 13574
4	10 59 54.57	+1.93	+16 2 22.5	−7.3	DM. 16°2210, Cin. Mer. Circle, 1 obs.
5	10 52 1.54	+1.90	+16 19 47.4	−5.5	⅕[Paris 13411+4 Wien 1873]
6	10 29 5.90	+1.44	+ 5 5 2.0	−6.1	½[Mun. I. 5474+Mun. II. 3303]
7	10 32 29.79	+1.43	+ 4 59 43.7	−6.1	½[Mun. I. 5544+Bonn 2364]
8	10 33 28.64	+1.34	+ 4 19 3.6	−6.0	Boss. A.G. Catal. 4090

OBSERVATIONS OF COMET *b* 1894,

MADE AT THE CINCINNATI OBSERVATORY,

BY PHILLIPS ISHAM.

1894 Cincinnati M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
h m s			m s	′ ″	h m s	° ′ ″		
May 12 8 23 8	9	8	+0 35.42	+ 0 34.1	9 38 3.00	+20 41 15.9	9.415	0.497
21 10 22 5	10	8	+0 9.82	+ 3 15.2	10 26 30.35	+32 45 17.7	9.645	0.397
26 11 5 50	11	8	+0 10.69	− 5 5.5	10 45 22.86	+36 19 3.8	9.727	0.488
28 9 26 2	12	9	+3 0.98	+ 0 46.5	10 51 50.88	+37 20 20.3	9.611	0.170
June 2 11 35 25	13	8	+2 50.50	+ 1 18.2	11 7 7.39	+39 24 39.2	9.765	0.536

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
9	9 37 26.40	+1.18	+20 40 39.1	+2.7	Paris 11958, Brux.4062, Glas.2524, Berl. A.G.Z.
10	10 26 18.99	+1.54	+32 11 57.5	+5.0	Leiden A.G.Z., 2 obs.
11	10 45 10.19	+1.68	+36 24 3.8	+5.5	Lund A.G.Z., 2 obs.
12	10 48 48.22	+1.68	+37 19 28.0	+5.8	⅓[2 Lund A.G.Z. + Yarnall 4644]
13	11 9 56.12	+1.77	+39 23 15.3	+5.7	Lund A.G.Z., 2 obs.

NEW ASTRONOMICAL WORK.

Beobachtungen des Neptunstrabanten am 30-zölligen Pulkowaer Refractor. von HERMANN STRUVE. St. Petersburg, 1894.

This memoir is from Volume XLII of the Imperial Academy of Sciences of St. Petersburg, and contains the observations of the satellite of *Neptune* in the seven years 1886-1893, made at Pulkowa by Dr. HERMANN STRUVE, together with a discussion of the observations and the deduction of a new orbit of the satellite. The measures are divided into four groups, each containing about forty complete observations of the angle of position and the distance of the satellite. Each observation consists of eight pointings for the distance, and the same for the angle. The measures of the angle were made in two sets, so that the means of the times for angle and distance are nearly the same. Different kinds of illumination were used, and great care was taken to avoid systematic errors. The angles were measured in two ways; by bisecting the planet and satellite, and by placing them between parallel wires. The first method proved the more accurate. The magnifying powers were 515, 630, and 900.

An investigation was made of the systematic errors of the angles, by observing twenty-two double stars. It has always seemed to us that the insertion of a small prism so that the angle could be changed to 0°, or 90°, or to any position, would be a good way of investigating this question. The distances were tested by measuring the angle between known stars, and the error was shown to be very small. In a distance of 2′ the mean difference is 0″.03.

In forming the equations of condition the polar formulas of MARTH were used, since they were found shorter and more convenient for the computation than those of BESSEL. The four groups of observations give eight groups of equations, and the residuals after solution show that the observations are excellent. The largest residual is 0″.599.

The values of the mean distances of the satellite are

	1887.62	$a =$	16″.285 ±0.028
	1889.02	"	16.272 ±0.019
	1890.61	"	16.253 ±0.021
	1892.60	"	16.293 ±0.032
Mean	1890.0	$a =$	16.271 ±0.012

In order to determine the mean motion of the satellite, and the motion of the orbit-plane, the observations of LASSELL, BOND and O. STRUVE are discussed. The mean daily motion of the satellite is found to be

$$n = 61^\circ.25748$$

The motion of the orbit-plane pointed out by MARTH in 1886 is confirmed. It appears to be proportional to the time, and if N be the node on the equator, and I the inclination, STRUVE finds that all the determinations can be represented by the equations

$$N = 185^\circ.15 + 0^\circ.148(t-1890)$$
$$I = 119.35 - 0.165(t-1890)$$

TISSERAND pointed out that this motion is probably produced by a flattening of the planet, and that a flattening of $\frac{1}{100}$ would produce the observed motion, if the planet be homogeneous.

The orbit of this satellite is nearly circular, since the values of the eccentricity found by all the observers lie between 0.003, and 0.010.

The resulting mean distance, 16″.271 ±0″.012, gives the mass of *Neptune*

$$\frac{1}{19396 \pm 43}$$

At the end of his memoir the author gives his determinations of the diameter of the planet as follows:

For yellow field illuminations	2″.120	5	observations
bright red "	2.197	10	"
dark red "	2.273	10	"

for log distance 1.4742. These show dependence of the illumination. Those by LASSELL and MARTH are

LASSELL,	2″.270	6	observations
MARTH,	2.289	5	"

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OBSERVATIONS OF COMET *b* 1894, BY MR. PHILLIPS ISHAM.
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ON THE INEQUALITIES IN THE COEFFICIENTS OF THE LAW OF LATITUDE-VARIATION,

BY S. C. CHANDLER.

In this paper it is proposed to attempt to find the definitive elements of the law of latitude-variation, including the inequalities in its various coefficients. This problem has long been in view, but I was not hopeful of a successful solution until the strikingly definite results obtained from POND's work satisfactorily bridged the gap between BRADLEY's and MOLYNEUX's Kew and Wanstead series and the modern observations, thus making the numeration of the periods elapsed during this long interval certain, and fixing within narrow limits the average length of the $428^d.6$-term. This provides a definite starting point for the detection of the oscillations of the four coefficients about their mean values. That such oscillations are present has been adverted to several times in the course of these papers.

In this investigation we can get no help from theory. Our standpoint in this regard is so low that we are in the dark as to what kind of variations may be expected *a priori*: and still more as to which of any observed variations in the coefficients stand in the relation of cause or effect to the others. For this reason no tenable objection can be urged against any simple empirical law which distinctly satisfies all our observations. Our only course for the present is to rely solely upon pure induction from observation, which has already led us safely to the knowledge of the general law, and enabled us to fix the average values of the constants with a precision which, notwithstanding their minuteness, and the recentness of our perception even of the existence of the phenomenon itself, seems to be comparable with that attained in the other fundamental constants of astronomy.

The present discussion is a definitive one, in the sense that no series of observations has been omitted which could materially improve the numerical values. It is based upon the nineteen determinations of the latitude-formula given in the following table. These were found from least-square solutions uniformly on the principles developed in *A.J.* 287. The reference-letters in the first column, from A to H, inclusive, are the same as given in *A.J.* 307, where a brief description of these series will be found. For the others a similar description is appended to the table here. The values of T_1 and G have all been referred to the Greenwich meridian, and the former to a common epoch (1865) by means of the period $428^d.6$.

OBSERVED VALUES OF COEFFICIENTS.

Series	p	t	T_1	r_1	G	r_2
				″	°	″
O	3	1828	240 2361.1	0.141	367.6	0.170
O	2	1833	2405.8	.134	377.0	.155
P	2	1840	2240.2	.059	361.5	.123
A	1	1843	2215.3	.077	347.2	.122
C	1	1845	2255.3	.035	297.4	.100
P	2	1847	2319.8	.092	347.4	.157
Q	1	1854	2215.8	.109	269.2	.142
Q	1	1861	2263.6	.088	305.5	.052
R	3	1866	2349.5	.120	269.5	.068
D	3	1867	2386.3	.235	274.1	.166
Q	1	1869	2361.7	.150	288.6	.148
E	3	1873	2365.1	.181	283.2	.088
Q	1	1876	2365.2	.088	275.0	.171
F	2	1877	2360.3	.236	329.7	.227
G	2	1882	2337.0	.152	290.1	.114
Q	1	1883	2354.6	.162	271.8	.093
Q	1	1888	2376.7	.171	312.8	.150
H	3	1891	2366.0	.142	343.6	.164
S	3	1892	240 2328.6	0.149	355.3	0.145

NOTES TO TABLE.

A, C, D, E, F, G, H. For description see *A.J.* 307.

O. Greenwich Mural-Circle observations of 36 stars, under POND; in two groups, 1825.3–30.6 and 1830.7–36.0. See *A.J.* 313, 315.

P. Greenwich Mural-Circle observations of 43 stars, under AIRY; in two groups, 1836.0–43.4 and 1843.5–51.0. See *A.J.* 319.

Q. Greenwich Transit-Circle observations of four close circumpolars; in six groups, 1851.0–58.0, 1858.0–65.0, 1865.0–72.0, 1872.0–79.0, 1879.0–86.0, 1884.6–91.6. The last two groups overlap. The numerical data from which these solutions were made were taken from THACKERAY's paper, *Mon. Not.* liii, 120 ff.

R. Leyden Meridian-Circle observations of *Polaris*, 1864.3–68.5. The solution was made from the data which I gave in *A.J.* 250.

S. Strassburg observations by TALCOTT's method, 1891.4–93.9. This solution is BECKER's, *A.N.* 3209.

I have limited the discussion to the European series, for the following reason. While the American series are suitable, and have been used, for deciding the question of the direction of the rotations, they are not sufficient to indicate whether both of these rotations are strictly circular, *i.e.*, exactly proportional to differences of longitude. If, as I suspect, this is not rigorously the case, the reductions to Greenwich, being large, may be sensibly in error and vitiate the results. The European series, being all comprised within a range of 30° in longitude, the reductions to a common meridian are small and appreciably correct unless one of the rotations is extremely eccentric.

The observed values of the constants in the above table are entered on the accompanying chart; the 428^d and annual terms being represented in the upper and lower parts, respectively. The arguments for the epochs are on the left, those for the amplitudes on the right. The linear vertical scales are different for the two terms. This mode of delineation was chosen in order to bring out perspicuously the characteristic features of the variations in the different coefficients, and the close mutual relations that appear to exist between them. These are visible at a glance, and are of a curious description. In the 428^d-term the departures from the mean values are manifestly systematic, and seem to obey the same law for epoch and amplitude. The minimum and maximum values of both occur about 1850 and 1880, respectively. In the annual term the departures of the epoch, G, are even more distinctly systematic, but the minimum lies about midway between the dates named. The variations in the amplitude of this term do not so distinctly appear on the chart, but if the weights of the points be attended to, the same likeness to those of the epochs seems to prevail here, as is the case in the first term.

This singular correlation of the observed deviations, and their general character, are strongly suggestive of a single common periodic law, with a cycle of 60 or 70 years. It is therefore proposed to test such a hypothesis by confronting it with the observed values of all four coefficients, on the assumption that they are simple functions of the same arbitrary angle.

The nature of the observed variations in the coefficients allows us to assume

$$\frac{dT_1}{dt} = w_1 \cos\Psi \qquad \frac{dG}{dt} = w_2 \sin\Psi$$

$$\frac{dr_1}{dt} = s_1 \cos\Psi \qquad \frac{dr_2}{dt} = s_2 \sin\Psi$$

Integrating, expressing Ψ as a function of the time, and taking convenient symbols for the new constants, we have

$$\left.\begin{array}{ll} \Psi = (t-\tau)\mu & \\ T_1 = T_1^0 + \omega_1 \sin\Psi & G = G^0 - \omega_2 \cos\Psi \\ r_1 = r_1^0 + \sigma_1 \sin\Psi & r_2 = r_1^0 - \sigma_2 \cos\Psi \end{array}\right\} (51)$$

The constants must be found by approximation. First, assuming $\mu = 6^\circ$, we get

$$\begin{array}{ll} T_1^0 = 2402325.4 \pm 6.5 & \omega_1 = 58.8 \pm 10.0 \\ G^0 = 315.3 \pm 3.8 & \omega_2 = 42.2 \pm \ 4.5 \\ r_1^0 = 0''.128 \pm 0''.006 & \sigma_1 = 0''.053 \pm 0''.009 \\ r_2^0 = 0''.136 \pm 0''.005 & \sigma_2 = 0''.023 \pm 0''.008 \end{array}$$

From the same solutions we get four independent values of the date τ,

$$1864.0 \pm 1.7 \ , \ 1865.2 \pm 1.7 \ , \ 1866.1 \pm 0.9 \ , \ 1859.4 \pm 4.8$$

the agreement of which within their probable errors affords a satisfactory index of the suitability of the adopted hypothesis. Proceeding, therefore, to a final determination, we first find τ and μ. From the solutions of the four independent sets of equations we have,

	τ	μ
From equations in T_1,	$1865.96 \pm 0^\circ.02$	$5^\circ.96 \pm 0^\circ.33$
" " " r_1,	1865.97 ± 0.02	5.57 ± 0.37
" " " G,	1866.00 ± 0.02	4.99 ± 0.30
" " " r_2,	1865.89 ± 0.08	4.53 ± 1.31

Thus the two terms of the latitude-variation give independently for μ, $5^\circ.78 \pm 0.25$ and $4^\circ.97 \pm 0.30$; corresponding to the periods 62.3 ± 2.7 and 72.4 ± 4.4 years, respectively for the 428^d and annual terms. There appears to be no sufficient reason, from the probable errors, without further evidence, to assume different values, and I therefore adopt $\mu = 5^\circ.48$ for both, corresponding to a period of 65.87 years. We have also $\tau = 1866.0 \pm 0.03$. The other solution gave the mean value 1865.1 ± 0.6. For convenience I adopt 1865.25, which corresponds to the time of minimum latitude from the 428^d-term in 1865.

A final solution, with these values of μ and τ, gives the other coefficients as follows:

$$\begin{array}{ll} T_1^0 = 2402327.3 \pm 6.5 & \omega_1 = 53.1 \pm 9.9 \\ G^0 = 316.8 \pm 4.1 & \omega_2 = 44.2 \pm 3.0 \\ r_1^0 = 0''.133 \pm 0''.007 & \sigma_1 = 0''.046 \pm 0''.007 \\ r_2^0 = 0''.136 \pm 0''.007 & \sigma_2 = 0''.018 \pm 0''.009 \end{array}$$

Adopting slightly rounded values we have finally, (52)

$$T_1 = 2402327 + 428.6\,E + 55 \sin\Psi \qquad G = 317^\circ - 44^\circ \cos\Psi$$

$$r_1 = 0''.135 + 0''.05 \sin\Psi \qquad r_2 = 0''.135 - 0''.02 \cos\Psi$$

in which $\Psi = (t-1865.25)\,5^\circ.48$ or $(t-2402327)\,0^\circ.015$ according as we express t in years or Julian days.

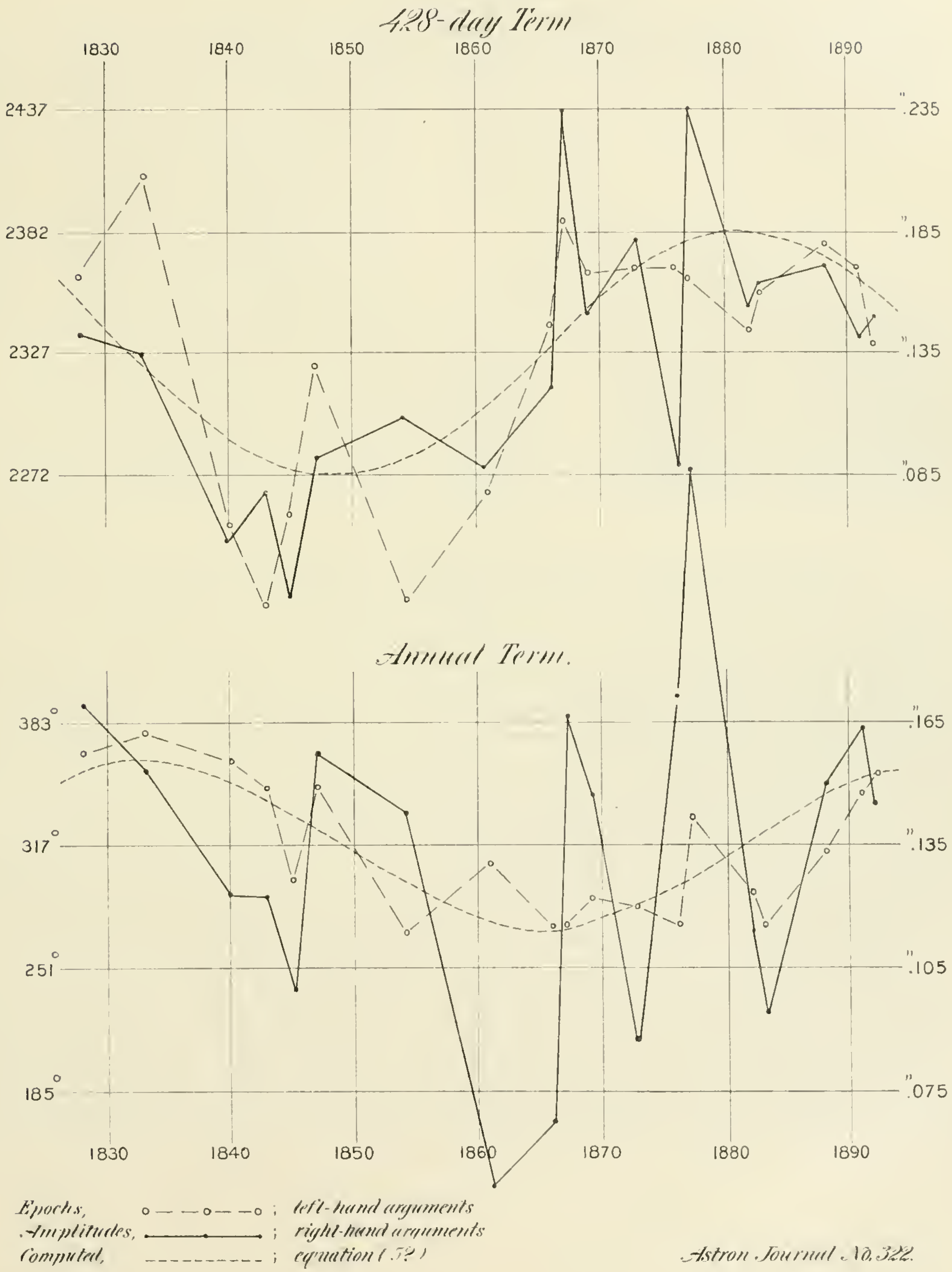
From the expression for T_1 we get the value of the period of the 428^d-term, according to this law, $428^d.6 + 5^d.26 \cos\Psi$; which varies between $423^d.3$ and $433^d.9$ in a period of 65.9 years. Similarly we find from the variation of G that the annual period varies between $361^d.0$ and $369^d.5$, in the same time.

We thus have a complete numerical theory for the constants in the general latitude-formula,

$$\varphi - \varphi_0 = -r_1 \cos[\lambda + (t - T_1)\theta] - r_2 \cos(\lambda + \odot - G)$$

which will satisfy the observations during three-quarters

Inequalities of Coefficients in Law of Latitude-Variation.



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of a century. The values computed from eq. (52) are given in a table below, and the resulting curves are also traced on the chart.

Elements of Latitude-Variation,
Computed from Eq. (52).

E	T_1	r_1	G	r_2
		″	°	″
−40	238 5236.5 = 1818 June 15.5	0.184	327.0	0.140
−35	7364.7 1824 Apr. 12.7	.170	348.2	.149
−30	238 9481.0 1830 Jan. 28.0	.146	359.9	.155
−25	239 1593.6 1835 Nov. 10.6	.118	358.5	.154
−20	3711.9 1841 Aug. 28.9	.096	344.3	.147
−15	5843.3 1847 June 30.3	.085	321.8	.137
−10	239 7991.5 1853 May 17.5	.090	297.9	.126
− 5	240 0154.7 1859 Apr. 19.7	.108	279.7	.118
0	2327.0 1865 Mar. 31.0	.135	273.0	.115
+ 5	4499.3 1871 Mar. 12.3	.162	279.7	.118
+10	6662.5 1877 Feb. 11.5	.180	297.9	.126
+15	240 8810.7 1882 Dec. 30.7	.185	321.8	.137
+20	241 0942.1 1888 Oct. 31.1	.174	344.3	.147
+25	3060.5 1894 Aug. 19.5	.152	358.4	.154
+30	241 5173.2 = 1900 June 2.2	0.124	359.9	0.155

Whether the empirical theory here presented corresponds to a real natural law can only be settled by future observation. It will be noted that the amplitude of the 428d-term will decrease during the next few years by an amount which ought to be appreciable from exact observation. The positive deviation of the epoch of the same term will also sensibly diminish. On the contrary, the corresponding values for the annual term will be almost constant, or very slightly increase. If the law thus developed by induction from observation be thus verified, it will serve as a touchstone in the attempt to discover the true dynamical theory of the earth's rotation.

In conclusion, we are now in a position to improve the table of predicted phases given in *A.J.* 307, (XIII, 162). If we take T_2 as the date corresponding to the sun's longitude G, we have the condition of the time of a maximum or minimum phase of the latitude-variation, for a place whose longitude is λ,

$$\theta r_1 \sin(t-T_1')\theta + 0^\circ.985\, r_2 \sin(t-T_2')\, 0^\circ.985 = 0$$

where $T_1' = T_1 - \frac{\lambda}{\theta}, \quad T_2' = T_2 - \lambda.$

Computed Phases for Berlin,
By Equation (52).

Minimum		Maximum		Period from	
Date	Amplitude	Date	Amplitude	Min.	Max.
	″		″		
1889 Jan. 24	−0.18	1889 Aug. 5	+0.24	392	394
1890 Feb. 20	− .27	1890 Sept. 3	+ .30	392	395
1891 Mar. 19	− .31	1891 Oct. 3	+ .31	396	392
1892 Apr. 18	− .29	1892 Oct. 30	+ .26	390	390
1893 May 13	− .22	1893 Nov. 24	+ .16	382	369
1894 May 31	− .10	1894 Nov. 28	+ .04	310	254
1895 Apr. 5	− .01	1895 Aug. 9	+ .05	304	376
1896 Feb. 3	−0.11	1896 Aug. 19	+0.16		

Cambridge, 1894 *June* 13.

LATITUDE-DETERMINATION AT THE SAYRE OBSERVATORY,

By C. L. DOOLITTLE.

The results of a preliminary reduction of this series of observations have been given in no. 311 of this Journal. The work is a continuation of that carried on here in former years, the general results of which may be found in *A.J.*, no. 274. It was the intention to resume observations in the early spring of 1892. A number of minor improvements were to be made in the building and instrument; among others, two levels were to replace the one formerly used. Owing to delays in obtaining tubes of the necessary delicacy, observations were first begun Oct. 10.

Both levels have been read before and after bisection with the micrometer, when time permitted; also three bisections have been made, in all cases. Oil lamps are, however, used for illumination, and there are other drawbacks which prevent obtaining as small a range as is possible under the best conditions. There is, however, a considerable improvement over the work of former years.

The star-list is, in the main, that employed in 1889, 90, — the most unfavorably situated pairs being replaced by others. A number of objectionable pairs have been retained, however, as it was not thought desirable to make many changes, otherwise the two series would not be directly comparable. Eleven groups were observed, embracing 107 pairs. Observations were carried on both before and after midnight, particular care being given to beginning with each group as early as possible in the morning twilight, and following it as long as possible in the evening, in order to obtain good connections between widely separated groups. One of the objects in view was the accumulation of data for a future discussion of the constant of aberration.

In the adjustment, as usual, the individual latitudes were first reduced to the mean of each group; the means were formed from the pairs of the old list only. Corrections were thus found for reducing the declinations of the new pairs to the mean system of the old ones.

For adjusting the groups to a common system twenty-six differences of latitude were obtained from observations covering the same, or nearly the same times. Each observed difference furnished one equation for this purpose.

Designating the groups in order by the Roman numerals the following differences with the corresponding weights were obtained.

	″	Wt.		″	Wt.
II–I	+0.058	8.89	V–II	+0.175	1.86
III–II	+ .056	8.43	VI–I	+ .100	3.68
IV–III	+ .050	2.22	VI–III	+ .101	4.92
V–IV	+ .072	2.94	VII–II	+ .197	1.51
VI–V	– .056	6.29	VIII–I	– .037	1.05
VII–VI	– .137	4.01	VIII–III	+ .053	2.58
VIII–VII	– .046	2.85	VIII–IV	– .157	1.31
IX–VIII	+ .042	3.28	IX–IV	+ .035	1.11
X–IX	– .099	4.67	IX–V	+ .155	1.14
XI–X	+ .175	4.35	X–II	– .226	1.75
I–XI	– .052	6.66	X–VI	– .044	3.00
IV–I	+ .100	1.49	XI–III	– .071	2.32
V–I	–0.021	2.00	XI–VII	+0.036	1.90

These values are not all strictly independent; for example, take II–I and IV–I, some of the observations upon I enter into both determinations, and similarly in other cases. This has not been taken into account in the assignment of weights.

The twenty-six equations resulting from these observed differences give by a least-square solution the following:

II–I	+0.0165	VIII–VII	–0.0178
III–II	+ .0278	IX–VIII	+ .0627
IV–III	+ .0412	X–IX	– .1399
V–IV	+ .0306	XI–X	+ .1175
VI–V	– .0186	I–XI	– .0626
VII–VI	–0.0574	Sum	0.0000

Adding these quantities, term by term, changing sign, and increasing each by 0.051* to make the mean of the corrections zero, we have the following as the quantities to be added to the latitude deduced from each group, to reduce it to the mean of all.

	″		″
I	+0.051	VII	+0.011
II	+ .035	VIII	+ .029
III	+ .007	IX	– .033
IV	– .034	X	+ .106
V	– .065	XI	–0.011
VI	–0.046		

In the tabular statement which follows, these corrections have been applied.

The probable error of a single observed latitude deduced from observations from December 1892 to April 1893, is

Winter	P.M.	366	observations	$r = 0.''206$
	A.M.	303	"	$r = 0.226$
1893 May–Aug.	P.M.	403	observations	$r = 0.178$
Summer	A.M.	212	"	$r = 0.193$

As was to be expected, the observations taken in summer are better than those of winter, and the evening observations are better than those of the morning. In fact, on winter mornings the conditions were frequently so bad as to raise grave doubts whether observations so made were of any value whatever. The choice was often between the alternatives of making observations under bad conditions or not at all, clear mornings being rare occurrences for weeks in succession.

The daily means given in the accompanying tabular statement will require no farther explanation.

DAILY MEANS OF LATITUDE.

$\varphi = 40° 36' 20''+$

Date	P.M.	Obs.	A.M.	Obs.
	″		″	
1892 Oct. 10	3.11	5	3.22	9
11	3.29	11	2.98	8
14	3.15	12	3.28	11
16			3.18	16
19	3.36	11	3.11	17
21	3.42	11	3.25	18
23	3.34	9	3.26	5
24	3.18	5		
30	3.03	14	2.96	12
Nov. 5	3.08	8		
8	3.16	12		
11	3.41	11		
13	3.16	15	3.20	11
16			3.15	13
17	2.97	11	3.66	4
22			3.01	11
26			3.16	13
Dec. 1	2.95	13		
2	3.13	14		
3	2.88	15		
5	3.00	14	3.34	12
9			3.56	8
10	3.01	15		
1892 Dec. 11			3.24	12
12	3.11	14		
15			3.24	3
17			3.02	15
18			2.98	11
20	2.92	11		
22			3.02	2
23	3.07	8		
25			3.19	8
26	3.03	15		
27	3.13	14	3.06	12
28	2.93	18	2.95	9
1893 Jan. 3			2.93	10
7			2.86	5
13	3.10	11		
16	3.11	11		
17	3.11	12		
19			2.94	12
20			2.87	7
21	2.83	18		
23	3.12	9		
25	2.97	18		
26	3.07	18		
1893 Feb. 3			3.00	9
4	2.79	16	3.21	10
8	3.19	13		
11			3.11	13
14	3.11	12		
15	2.90	7	3.14	11
16			2.96	11
20	2.77	20		
24	2.79	6		
25			2.78	8
26	2.96	20	3.24	11
Mar. 1	2.84	14	2.83	10
6	2.97	16		
7	2.91	15	2.81	4
13	3.13	14	3.13	6
16	3.02	7		
17			3.15	8
18	2.87	21	3.11	8
21	3.08	5		
27	2.94	20	2.97	7
28	2.79	20	2.92	8
29	3.03	21	3.22	7
Apr. 2	2.89	17		

---

* This should have been 0.047. The error was not discovered until after the corrections had been applied. It is not important.

Date	P.M.	Obs.	A.M.	Obs.
	″		″	
1893 Apr. 4	3.05	6	2.71	9
16	3.06	11		
17			3.15	11
18			3.09	10
23			3.09	6
24	2.75	19		
25	2.96	2	2.72	8
28	2.81	17		
May 6	2.85	14	2.95	9
7	2.98	15	3.07	8
8	2.81	15		
9	2.88	17		
10	3.01	19		
11			3.08	10
12	2.87	14		
19	3.02	16	3.05	11
31	3.06	13		
June 7	3.01	12	3.30	12
8	2.95	18	3.13	11
9	3.00	17	3.19	13
11	2.93	14	3.12	2
13	2.97	18		
14			3.00	10
17			3.23	14
20	3.06	14		
23	3.08	15	3.07	8
24	3.08	14		
28			3.25	14
30			3.01	14
July 2	3.19	18		
5			3.30	12
7	3.05	9		
9	3.14	19	3.19	13
10	3.11	19	3.29	11
1893 July 11	2.85	12		
16	3.18	9		
17	3.06	11	3.29	12
18	2.87	8	3.17	11
19	3.03	11	3.28	13
20	3.14	16		
23			3.24	16
27	2.99	18		
29	3.10	18		
30	3.12	16		
Aug. 2			3.33	8
5	2.99	16	3.34	9
6			3.28	10
7	3.45	2	3.23	10
8	3.20	18	3.19	10
9	3.03	18	3.24	10
10			3.13	10
Sept. 2	3.23	17	3.13	9
3	3.23	16	3.31	5
6	3.10	17		
8	3.11	17	3.18	10
9	3.19	16		
12	3.11	14		
16	3.16	11		
17			3.19	6
19			3.14	6
20			3.25	14
21			3.13	12
23			3.26	16
27	3.22	16		
28	3.32	13		
29	3.10	17	3.25	8
30	3.38	18	3.46	8
Oct. 1	3.14	16	3.38	9
1893 Oct. 2			3.24	7
3	3.20	11		
4			3.07	9
8			3.19	8
9			3.05	9
14	3.20	17		
17	3.38	18		
18	3.16	17		
20	3.37	6	3.03	9
21	3.27	5	3.53	9
24	3.20	18	3.20	11
30			3.45	9
31	3.31	18	3.21	11
Nov. 3	3.17	9		
6	3.30	18	3.39	11
10	3.32	19	3.42	12
11	3.31	19	3.39	12
15	3 24	18	3.16	10
16	3.32	19		
26	3.19	19		
30	3.24	18		
Dec. 4	3.19	18	3.32	5
5			3.12	10
6	3.24	16		
7	3.24	10	3.38	7
10	3.11	10	3.19	10
12	2.91	9		
13	3.13	10	3.48	6
17	3.33	1	3.36	9
20	3.24	10		
23	2.80	8		
24	3.14	10	3.09	10
25	2.81	10	3.22	7
26	3.20	10	3.29	9
27			3.06	9

Combining these for the same periods as those of the preliminary values (*A.J.* 311), we have

	P.M.	No.	A.M.	No.	½(AM+PM)	(AM−PM)
	″		″		″	
1892 Oct. 10–Oct. 24	3.283	64	3.183	84	3.233	−0.100
Oct. 30–Nov. 17	3.137	71	3.159	40	3.148	+ .022
Nov. 20–Dec. 5	2.985	56	3.173	36	3.079	+ .188
Dec. 9–Dec. 26	3.031	63	3.164	59	3.097	+ .133
Dec. 27–Jan. 13	3.039	43	2.966	36	3.002	− .073
1893 Jan. 16–Jan. 26	3.014	86	2.914	19	2.964	− .100
Feb. 3–Feb. 16	2.994	48	3.086	54	3.040	+ .092
Feb. 20–Mar. 7	2.884	91	2.952	33	2.918	+ .068
Mar. 13–Mar. 21	2.991	47	3.130	22	3.060	+ .139
Mar. 27–Apr. 4	2.925	84	2.936	31	2.931	+ .011
Apr. 16–Apr. 28	2.848	49	3.025	35	2.936	+ .177
May 6–May 12	2.903	94	3.033	27	2.968	+0.130
1893 May 19–June 8	3.005	59	3.166	34	3.085	+0.161
June 9–June 20	2.990	63	3.151	39	3.070	+ .161
June 23–June 30	3.081	29	3.115	36	3.098	+ .034
July 2–July 20	3.081	132	3.251	72	3.166	+ .170
July 25–Aug. 10	3.080	106	3.244	83	3.162	+ .164
Sept. 2–Sept. 21	3.161	108	3.186	62	3.173	+ .025
Sept. 25–Oct. 9	3.225	91	3.235	74	3.230	+ .010
Oct. 14–Oct. 30	3.244	81	3.298	38	3.271	+ .054
Oct. 31–Nov. 16	3.289	120	3.320	56	3.304	+ .031
Nov. 26–Dec. 13	3.174	110	3.269	38	3.221	+ .095
Dec. 20–Dec. 27	3.056	49	3.199	44	3.127	+0.143
Total		1744		1052		+0.075

The systematic difference between the morning and evening values is very marked. This is presumably due, in part at least, to the employment of too small a value for the constant of aberration, viz: STRUVE's. We may obtain a rough idea of the correction indicated. by comparing this value with the total correction for aberration—the terms

$Cc'+Dd'$ in the reduction to apparent place. The mean values in this case are, for

Morning, $Cc'+Dd' = -10''.00$
Evening, $+\ 9.15$
Difference, 19.15

Bethlehem, Pa., 1894 *June* 11.

Dividing the above quantity 0.075 by this difference it indicates an increase of STRUVE's constant by the amount 0.0039 × 20.445 = 0.080, giving a value 20″.525.

As it is the intention to deduce from my observations a value of this constant, this subject will not be pursued further at present.

SUNSPOT OBSERVATIONS,

MADE AT PHILADELPHIA, PENN., WITH A 4½-INCH REFRACTOR,

BY A. W. QUIMBY.

1894	Time	New Gps.	Total		Fac. Grs.	Def.
			Gps.	Spots		
Jan. 2	11	1	8	38	3	poor
3	2	1	5	26	2	poor
4	12	–	5	26	2	poor
5	10	2	6	25	2	poor
6	10	–	5	19	2	poor
7	4	–	1	3	–	v. poor
8	10	–	4	22	–	v. poor
12	9	3	4	36	2	poor
13	10	1	5	34	2	poor
14	10	2	7	55	3	poor
15	9	1	7	42	1	poor
16	9	1	7	31	–	poor
17	2	2	9	60	3	poor
19	11	2	11	52	4	poor
20	10	–	11	65	2	fair
21	9	–	9	14	–	v. poor
22	9	–	9	19	2	poor
23	12	3	10	48	2	good
24	12	1	11	43	2	poor
25	12	–	11	73	2	fair
26	10	–	8	80	2	fair
27	2	–	5	66	3	fair
28	10	–	5	55	4	poor
30	2	–	4	13	1	v. poor
31	10	–	4	9	–	v. poor
Feb. 1	9	1	4	19	–	poor
2	9	1	6	65	2	fair
5	10	1	5	25	2	poor
6	12	1	6	42	3	poor
7	4	1	7	67	2	fair
8	11	1	6	42	4	poor
10	9	2	7	67	2	good
11	9	–	8	38	3	fair
13	4	–	6	24	–	poor
14	3	1	7	23	2	poor
15	2	2	8	25	3	poor
16	10	–	8	37	5	good
17	9	–	7	21	3	poor
18	9	1	7	42	3	fair
19	2	3	9	78	3	fair
20	10	–	8	128	3	fair
21	11	1	9	110	3	fair
22	9	–	7	102	2	fair
23	10	–	6	67	2	poor
24	10	1	7	43	2	poor
25	10	–	7	48	2	poor
Feb. 26	2	–	2	8	–	v. poor
27	12	2	8	40	1	poor
28	10	–	7	40	1	poor
Mar. 1	10	–	4	20	3	fair
2	10	1	5	13	5	fair
3	9	–	4	5	5	poor
4	9	4	7	12	7	fair
5	9	–	5	13	5	poor
6	9	–	5	23	5	fair
7	9	–	4	25	2	fair
8	8	2	5	18	2	poor
9	8	–	3	17	2	poor
10	12	1	5	37	2	poor
12	12	–	4	21	–	poor
13	8	–	4	16	1	poor
14	9	–	6	43	3	good
15	9	–	6	22	3	poor
16	2	–	4	11	4	fair
17	9	–	4	6	4	poor
18	8	–	3	3	4	poor
19	8	–	2	2	2	poor
20	3	2	3	11	3	fair
22	9	1	3	26	3	fair
23	9	2	5	31	3	fair
24	8	–	4	20	3	fair
26	9	2	5	25	3	fair
27	9	–	4	28	4	fair
28	9	2	7	57	5	fair
29	5	–	5	24	2	poor
30	8	–	7	62	4	fair
31	9	1	6	100	3	fair
Apr. 1	9	–	4	60	2	poor
2	9	–	5	95	3	fair
3	9	–	5	84	2	fair
5	8	5	10	75	3	good
6	9	–	9	98	2	fair
7	8	–	7	80	2	fair
8	2	–	6	84	2	fair
9	9	1	6	74	3	fair
12	9	–	3	40	2	poor
13	9	–	2	57	3	poor
14	8	2	4	89	6	good
15	8	–	3	43	4	fair
16	8	–	3	18	3	fair
17	8	–	3	18	3	fair
18	8	–	3	21	3	fair
Apr. 19	11	2	5	37	3	fair
20	10	–	5	42	3	fair
21	9	–	5	33	3	fair
22	9	4	9	96	3	fair
23	8	–	9	124	4	good
24	8	1	9	106	4	good
25	8	–	8	98	3	fair
26	8	2	9	105	4	good
27	8	–	7	96	3	good
28	7	–	9	72	2	good
29	7	–	10	52	3	fair
30	7	1	10	54	3	fair
May 1	7	1	10	54	3	fair
2	6	–	10	37	4	poor
3	6	–	9	44	2	poor
4	4	1	9	30	3	poor
5	3	–	8	34	2	poor
6	8	–	6	30	2	poor
7	8	–	8	75	2	fair
8	7	1	9	73	3	fair
9	7	1	9	54	5	fair
10	7	–	8	48	5	fair
11	7	–	5	34	2	poor
12	7	2	7	58	3	fair
13	8	–	4	59	5	fair
14	7	2	5	106	3	fair
15	9	1	6	187	3	fair
16	7	–	5	154	3	fair
17	7	1	6	106	2	poor
18	4	2	10	178	2	fair
19	9	1	11	166	4	fair
23	10	1	6	106	2	fair
24	9	1	7	48	2	poor
25	8	–	7	46	2	poor
26	8	–	6	28	2	fair
27	8	–	6	26	2	fair
28	7	3	9	30	4	fair
29	8	–	8	42	3	fair
30	5	1	8	40	2	fair
31	12	–	7	11	2	poor
June 1	8	1	9	33	2	fair
2	8	–	9	24	1	poor
3	8	–	10	41	2	good
4	7	3	10	40	2	fair
5	5	1	9	54	2	poor
7	7	1	8	86	2	fair

1894	Time	New Gps.	Total Gps.	Total Spots	Fac. Grs.	Def.	1894	Time	New Gps.	Total Gps.	Total Spots	Fac. Grs.	Def.	1894	Time	New Gps.	Total Gps.	Total Spots	Fac. Grs.	Def.
June 8	7	–	7	53	3	fair	June 16	7	–	8	68	2	fair	June 24	8	1	8	25	3	fair
9	7	1	8	85	3	good	17	7	–	8	97	3	fair	25	8	–	6	16	3	fair
10	8	1	9	102	4	fair	18	7	–	8	136	3	good	26	8	1	6	34	1	good
11	8	–	6	97	2	good	19	8	1	7	155	3	good	27	8	–	6	16	1	fair
12	8	1	8	105	3	good	20	7	1	7	120	4	good	28	–	–	6	34	1	fair
13	5	1	9	66	2	poor	21	7	–	7	106	3	good	29	–	–	6	38	3	fair
14	7	–	9	67	3	poor	22	7	–	7	82	4	good	30	12	–	6	34	2	fair
15	7	–	9	80	2	poor	23	7	3	8	65	4	good							

OBSERVATIONS OF COMETS,

MADE WITH THE 16-INCH EQUATORIAL AND FILAR MICROMETER OF GOODSELL OBSERVATORY, AT NORTHFIELD, MINN.,

By H. C. WILSON.

[Communicated by Wm. W. Payne, Director.]

1894 Northfield M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
			Comet *a* 1894 (Denning).					
	h m s		m s	′ ″	h m s	° ′ ″		
Apr. 23 10 53 37	1	9 , 4	−3 40.44	+5 57.6	11 13 17.75	+18 6 59.2	9.309	0.614
25 9 53 51	2	9 , 6	+2 36.94	−0 58.7	11 17 17.69	+17 17 48.2	9.006	0.608
27 9 32 40	3	11 , 6	−0 10.96	−4 8.1	11 21 15.62	+16 29 13.8	8.837	0.617
May 3 10 15 49	4	10 , 6	−0 0.64	−2 50.4	. . .	. . .	9.227	0.658
			Comet *b* 1894 (Gale).					
May 3 9 7 20	5	9 , 6	−0 47.96	+1 31.6	. . .	. . .	. . .	. . .
9 7 20	6	9 , 6	−1 42.41	−2 25.6	8 20 22.38	− 6 6 6.1	9.534	0.815
16 9 31 30	7	9 , 6	+0 52.46	+4 6.6	10 2 21.61	+27 22 11.8	9.541	0.544
9 31 30	8	9 , 6	+0 10.64	+3 13.5	10 2 21.37	+27 22 11.3	. . .	. . .
24 9 8 59	9	9 , 6	+1 53.81	−1 16.6	10 37 58.75	+35 2 52.4	9.524	0.359
9 8 59	10	6 . 6	+0 24.60	−1 11.9	10 37 58.99	+35 2 51.3	. . .	. . .
30 9 45 8	11	9 , 6	−2 48.06	−4 57.2	10 58 14.57	+38 15 34.8	9.617	0.370
June 4 10 56 8	12	9 , 6	+0 47.52	−2 28.8	11 12 32.14	+40 2 6.5	9.726	0.491
5 11 17 0	13	9 , 6	−0 33.40	−5 53.7	11 15 11.55	+40 19 1.8	9.728	0.561
7 11 12 47	14	9 , 6	−0 10.43	+3 11.0	11 20 14.09	+40 49 10.2	9.730	0.553
19 10 3 37	15	6 , 4	−4 1.43	+6 5.0	11 46 55.23	+42 42 35.1	9.707	0.407
22 10 12 44	16	9 , 5	−0 45.71	−5 21.0	11 52 56.96	+42 58 8.5	9.722	0.444

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	11 16 56.33	+1.86	+18 1 6.6	−5.0	Yarnall 4846, Gr. 10-year, Brussels 4678
2	11 14 38.91	+1.84	+17 18 51.8	−4.9	W. Bessel XI, 233. Lalande gives for the seconds of R.A. 39.52s; Decl. 24″.5
3	11 21 24.74	+1.84	+16 33 27.3	−5.4	W. Bessel XI. 354
4	11 32 40	+1.77	+14 10	−6.0	DM. 14°2414
5	8 21 9	. .	− 6 8	. .	DM. −6°2591
6	8 22 4.30	+0.49	− 6 3 37.3	−3.2	Karlsruhe Observations 1885
7	10 1 27.79	+1.36	+27 18 1.0	+4.2	W. Bessel IX. 1266
8	10 2 9.37	+1.36	+27 18 53.6	+4.2	W. Bessel IX, 1287, 8
9	10 36 3.32	+1.62	+35 4 3.6	+5.4	B.B. VI, 35°2174
10	10 37 32.76	+1.63	+35 3 58.1	+5.3	W. Bessel X. 719
11	11 1 0.89	+1.74	+38 20 26.3	+5.7	B.B. VI. 38°2210
12	11 11 42.85	+1.77	+40 4 29.4	+5.9	W. Bessel XI, 168
13	11 15 43.16	+1.79	+40 24 49.7	+5.8	W. Bessel XI, 243
14	11 20 22.70	+1.82	+40 45 53.5	+5.7	W. Bessel XI. 336
15	11 50 54.82	+1.84	+42 36 24.8	+5.4	Lalande 22488
16	11 53 40.85	+1.82	+43 3 24.1	+5.4	B.B. VI, 43°2172

REMARKS.

April 25. There is an uncertainty of 5^m in the time of this observation. The marking of the chronograph sheet at the end of the observation would make the time 5^m earlier.

April 27. Comet very faint; observation difficult.

May 3. DENNING's comet exceedingly faint; near an 11^M star.

May 24. Searched carefully in the place of DENNING's comet with clear sky, but could not see it.

GALE's comet has in all the observations been an easy object for micrometric measurement, having a well-defined, almost stellar nucleus up to the last.

EPHEMERIS OF *CHALDAEA* (313),

BY LEWIS BOSS.

This ephemeris is computed from the elements of Mr. BERBERICH as given in the *Berliner Jahrbuch* for 1896. From an observation at Albany, June 28.5, the correction required by the ephemeris on that date was:

$$\Delta\alpha = +1^m\,43^s.0\,; \quad \Delta\delta = +2'\,18''.$$

The opposition occurs July 5, and the magnitude given by the *Jahrbuch* for that epoch is $11^M.1$. The planet appears to be somewhat fainter than this.

EPHEMERIS FOR BERLIN MIDNIGHT.

	App. α	App. δ	log r	log Δ
	h m s	° ′		
June 27	19 6 22	−5 3.6	0.4383	0.2479
29	4 29	−5 6.7	0.4386	0.2468
July 1	2 36	−5 10.5	0.4389	0.2464
3	19 0 41	−5 14.9	0.4391	0.2463
5	18 58 45	−5 19.9	0.4394	0.2464
7	56 50	−5 25.5	0.4397	0.2467
9	54 56	−5 31.8	0.4400	0.2474
11	53 2	−5 38.6	0.4402	0.2483
13	51 11	−5 45.9	0.4405	0.2494
15	18 49 22	−5 53.7	0.4407	0.2508
July 17	18 47 36	−6 2.1	0.4410	0.2525
19	45 51	−6 10.8	0.4412	0.2544
21	44 10	−6 20.1	0.4414	0.2565
23	42 33	−6 29.7	0.4417	0.2588
25	41 0	−6 39.6	0.4419	0.2614
27	39 31	−6 50.0	0.4421	0.2642
29	38 6	−7 0.6	0.4423	0.2672
31	36 46	−7 11.5	0.4426	0.2704
Aug. 2	35 37	−7 22.6	0.4428	0.2737
4	34 23	−7 34.0	0.4430	0.2773
6	33 20	−7 45.5	0.4432	0.2810
8	32 22	−7 57.2	0.4434	0.2848
10	31 31	−8 9.0	0.4436	0.2888
12	30 45	−8 20.8	0.4438	0.2930
14	30 6	−8 32.8	0.4440	0.2972
16	29 33	−8 44.7	0.4442	0.3015
18	29 5	−8 56.7	0.4444	0.3060
20	28 44	−9 8.6	0.4446	0.3105
22	28 30	−9 20.5	0.4447	0.3151
24	28 21	−9 32.4	0.4449	0.3198
26	28 18	−9 44.2	0.4451	0.3245
28	18 28 22	−9 55.8	0.4452	0.3293

EPHEMERIS OF COMET *b* 1894,

REV. G. M. SEARLE.

As the observations in June show very little correction to the ephemeris given in *A.J.* 319, it is continued as follows:

EPHEMERIS FOR GREENWICH MIDNIGHT.

1894	α	δ	log Δ	Brightn.
	h m s	° ′		
July 11.5	12 25 24	+40 52.5	0.3041	
12.5	26 44	40 34.6		
13.5	28 2	40 17.0	.3191	0.06
14.5	29 19	39 59.8		
15.5	30 34	39 43.0	.3334	
16.5	31 48	39 26.6		
17.5	33 1	39 10.5	.3470	0.05
18.5	34 12	38 54.8		
19.5	12 35 23	+38 39.5	0.3600	
July 20.5	12 36 33	+38 24.6		
21.5	37 42	38 10.0	0.3726	0.04
22.5	38 50	37 55.8		
23.5	39 57	37 41.9	.3847	
24.5	41 3	37 28.3		
25.5	42 9	37 15.1	.3964	0.03
26.5	43 14	37 2.2		
27.5	44 18	36 49.5	.4076	
28.5	45 22	36 37.1		
29.5	46 25	36 25.0	.4185	0.03
30.5	47 28	36 13.1		
31.5	48 30	36 1.5	.4291	
Aug. 1.5	49 32	35 50.1		
2.5	12 50 34	+35 38.9	0.4394	0.02

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VARIATION OF LATITUDE AT SAN FRANCISCO, 1891–1892, ACCORDING TO OBSERVATIONS OF PROF. GEORGE DAVIDSON,

LETTER FROM T. C. MENDENHALL, SUPERINTENDENT U. S. COAST AND GEODETIC SURVEY.

It gives me much pleasure to be able to send you the results for variation of latitude at the third and last station occupied by this office, with a view of further elucidating this phenomenon. Full publication has been made for the stations Waikiki, near Honolulu, and Rockville, near Washington, D.C., in Appendices Nos. 1 and 2 of Report for 1892. I now send you an account in abstract form of the results reached from the discussion of a very extensive series of observations made by TALCOTT's method at San Francisco, California. These observations comprise no less than 6768 individual latitude results, and are due to the perseverance of Assistant GEORGE DAVIDSON.

This extensive work was commenced May 27, 1891, and terminated August 19, 1892. Mr. DAVIDSON used two instruments, the first a zenith-telescope of old form (aperture of telescope $8\frac{1}{4}$ cm.), to which, later on, two levels were supplied; the second a zenith-telescope improved and similar to that used at Rockville (aperture $7\frac{1}{2}$ cm.), also supplied with new levels. The place occupied is south of the Golden Gate, in latitude 37° 47′ 28″.3, and in longitude 122° 25′ 42″, or 8^h 9^m $42^s.8$ W. of Greenwich, and is elevated 115.6 metres above the mean sea level. The values of the micrometer-screws of these instruments were very carefully determined. For the first instrument 12 series of observations on circumpolar stars gave the result, 1 turn = 100 div's = 47″.596 ± 0″.008; and 15 series of observations for the second instrument gave 1 turn = 100 div's = 47″.636 ± 0″.005. The inequalities of these screws were carefully investigated, and corrections to the readings were applied for irregularity in whole turns, and for periodic inequality in fractional parts. It is well known that the climatic conditions at this place are very unfavorable for accurate work, and this is shown by the fact that the probable error of observation for latitude with the first instrument was as high as ± 0″.28, and with the second instrument ± 0″.19. However, no other station could be had without involving extra expense, and the final results will be found no less satisfactory, which is due to the large number of observations.[*] The mean places of stars depend on the AUWERS–BOSS system for declinations, and the apparent places were computed from the independent day numbers in the American Ephemeris.

The following table shows the statistics of the arrangement as carried out by the observer:

Group	No. of pairs	No. of series	Total number of observations in group
I	14	37	278 and 924
II	17	53	771 " 627
III	16	27	528 " 192
IV	17	21	497
V	21	15	682
VI	19	16	811
VII	23	23	789
VIII	18	14	669

Groups I, II, III were reobserved the second year. The number of series is only that from which the group-mean is derived.

The reduction of the whole series was placed in charge of the Computing Division of this Office, and carried out on the same lines as for the other two stations. The final corrections to the group-means were small, the greatest amounting to 0″.13. The number of nights of observation is 237, and the resulting values for latitude were condensed into 57 mean values by combining the whole series into means of 4 days (with a few of 5 days) each, as shown in the accompanying diagram, which demands no further explanation.

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[*] Our observers at Waikiki and Rockville found for ϵ, the values ± 0″.21 and ± 0″.17, respectively.

For the purpose of expressing the variation by a periodic function the above values were further concentrated into 29 normal values, as follows; these may be regarded as the direct outcome of the work done at this station.

No.	Date 1891	No. of obsns.	Latitude 37° 47′+	No.	Date 1891–92	No. of obsns.	Latitude 37° 47′+
			″				″
1	May 31	174	28.42	16	Dec. 25	247	28.24
2	June 12	204	.37		1892		
3	June 23	201	.38	17	Jan. 13	260	.29
4	July 4	223	.50	18	Jan. 22	331	.36
5	July 16	247	.41	19	Feb. 5	313	.32
6	July 32	195	.25	20	Mar. 6	318	.38
7	Aug. 14	194	.18	21	Mar. 24	195	.46
8	Sept. 2	172	.22	22	Apr. 5	272	.50
9	Sept. 18	207	.12	23	Apr. 18	243	.46
10	Sept. 28	240	.04	24	Apr. 29	188	.56
11	Oct. 11	234	.16	25	May 12	275	.51
12	Oct. 31	143	.10	26	May 23	264	.49
13	Nov. 12	278	.15	27	June 24	240	.48
14	Nov. 21	289	.08	28	Aug. 9	274	.44
15	Dec. 8	202	28.16	29	Aug. 18	145	28.36

In accordance with Dr. CHANDLER's researches these values have been represented by a function of two periodic terms, one of 431 days, the other of 365¼-day periods; thus we have the expression

$$\varphi = \varphi_0 + r_{\mathrm{I}} \sin\left(\frac{2\pi}{P_{\mathrm{I}}} t + \alpha\right) + r_{\mathrm{II}} \sin\left(\frac{2\pi}{P_{\mathrm{II}}} t + \alpha\right)$$

Taking t, or number of days, to count from 1891 January 0, as epoch, and applying the method of least-squares, we get

$$\begin{aligned}\varphi = 37^\circ\, 47'\, 28''.334 &+ 0''.171 \sin(0.83526\, t + 3^\circ.7)\\ &+ 0''.074 \sin(0.98563\, t + 20^\circ.5)\end{aligned}$$

This formula leaves the differences of computed and observed values as follows:

No.	C—O	No.	C—O	No.	C—O
	″		″		″
1	+0.06	11	−0.04	21	0.00
2	+ .08	12	+ .02	22	−0.01
3	+ .03	13	− .02	23	+ .04
4	− .14	14	+ .06	24	− .05
5	− .12	15	+ .01	25	+ .01
6	+ .03	16	− .03	26	+ .03
7	+ .05	17	− .02	27	+ .01
8	− .04	18	− .07	28	− .04
9	+ .03	19	+ .01	29	+0.01
10	+0.09	20	+0.04		

$$\left.\begin{array}{ll}\text{Minimum, 1891 Oct. 22,} & \varphi = 37^\circ\, 47'\, 28''.118\\ \text{Maximum, 1892 May 15,} & 28''.517\end{array}\right\}\ \text{range } 0''.399$$

While the observations at our three stations plainly indicate the revolution of the instantaneous pole of rotation about that of the axis of principal moment in the direction from west to east, and at a distance of about 0″.2 at the present time, it is of great interest to compare the results of Dr. CHANDLER's researches directly with experience, since finally we shall have to depend on expressions which extend over the whole range of time covering all our observed latitudes, which it is now known demand small corrections to reduce them to what may be termed the normal latitude of a place. The lower part of the diagram,* together with parts for Waikiki, Rockville and Berlin (about the periods of minima), were thus computed and laid down from CHANDLER's formula (48) in *A.J.*, 307, viz.:

$$\begin{aligned}\varphi - \varphi_0 = &-0''.15 \cos[\lambda + (t - 1875 \text{ Nov. } 1)\, 0^\circ.83527]\\ &-0''.15 \cos(\lambda + \odot - 320^\circ)\end{aligned}$$

where t is the number of days elapsed since the Julian date of 1875 Nov. 1. It is very gratifying to see so close a correspondence between prediction and observation, and it may be noted here that according to the same formula the variation in latitude during the present year would be very small, probably less than 0″.1; to test which some additional observations for latitude were made at San Francisco by the same observer, but of these observations an account can only be given at some future time.

Washington, D.C., 1894 *June* 29.

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* Dr. MENDENHALL's letter is accompanied by a diagram showing, as stated, a close correspondence between the computed and observed curves. — ED.

ON SOME FURTHER CHARACTERISTICS OF THE POLAR ROTATION,

BY S. C. CHANDLER.

While engaged in the previous investigations, I have often recurred to the question whether there is any evidence that either component of the polar rotation deviates from a uniform circular motion. But the matter of proof was so evasive, from the material at hand, that it has been held in abeyance. While there was strong ground for suspicion of such a phenomenon, its publication did not seem warranted, and the matter was only alluded to in no. 322 (p. 74) as a justification for limiting the determination of the coefficients there made to the European series exclusively.

Meanwhile the results of a part of Prof. GEORGE DAVIDSON's beautiful series at San Francisco, have been made known. His fortunate situation, in a longitude about midway between the eastern American coast and the Sandwich Islands, enables us to examine this problem with some little prospect of definite result.

For the revolution of the terrestrial poles which took place between the summers of 1891 and 1892 we have published determinations of the latitude-coordinate made in seven different localities, tolerably well distributed over 188° of longitude. The following table gives normal values of these latitude-variations, for equidistant intervals of 50 days from 1891 June 16 to 1892 July 20 (Julian dates 241 1900–241 2300). They were found by comparing the observed data with an assumed curve, furnished by eq. (52), and applying the deduced mean differences O−C to the computed values for the adopted normal dates. The series of observations employed are,

Series	Place	λ	Observer
		°	
I	Pulkowa	− 30.3	Kostinsky
II	Prague	− 14.4	Weinek & Gruss
III	Berlin	− 13.5	Marcuse & Battermann
IV	Strassburg	− 7.8	Becker
V	Rockville	+ 77.1	Smith
VI	San Francisco	+122.4	Davidson
VII	Waikiki	+157.8	Preston
VIII	Waikiki	+157.8	Marcuse

All the determinations, except I, were by TALCOTT's method.

t	I	II	III	IV	V	VI	VII	VIII
	″	″	″	″	″	″	″	″
241 1900	–	−.12	−.03	–	+.30	+.13	+.10	+.05
1950	+.08	+.12	+.18	+.18	+.13	−.04	−.21	−.18
2000	+.26	+.27	+.30	+.31	−.05	−.21	−.33	−.26
2050	+.26	+.25	+.24	+.25	−.21	−.19	−.23	−.23
2100	+.10	+.09	+.03	+.04	−.19	−.09	−.09	−.05
2150	−.11	−.11	−.21	−.18	−.07	+.06	+.14	+.14
2200	−.23	−.22	−.34	−.28	+.13	+.18	+.35	+.24
2250	−.22	–	–	−.21	+.21	+.21	+.20	+.20
241 2300	−.04	–	–	−.02	+.06	+.16	.00	–

If we call α the longitude of the pole of figure, reckoned from west to east from the meridian drawn from the pole of rotation through Greenwich, and call r the distance between the two poles at the same instant; then the difference between the observed and mean latitude of a place whose terrestrial longitude is λ, reckoned in the usual manner from east to west, will be

$$\varphi-\varphi_0 = -r\cos(\alpha+\lambda)$$

Transforming to a system of rectangular coordinates whose positive y-axis is directed towards Greenwich, we have $x = r\sin\alpha$, $y = r\cos\alpha$, and

$$x\sin\lambda - y\cos\lambda = \varphi-\varphi_0$$

For each date we have as many equations of this form as there are places of observation. The solution by least-squares will give α and r for the various dates. We thus obtain from the above table,

t	x	y	α	r
	″	″	°	″
241 1900	+0.212	−0.002	90.7	0.212
1950	+ .083	− .197	157.1	.214
2000	− .070	− .282	193.0	.290
2050	− .197	− .184	227.0	.270
2100	− .162	− .010	266.4	.163
2150	− .041	+ .172	346.6	.177
2200	+ .135	+ .242	29.1	.277
2250	+ .213	+ .134	57.8	.252
241 2300	+0.117	−0.003	91.5	0.117

It is scarcely necessary to observe that these values are absolutely independent of any assumption as to the law of the polar rotation, and furnish a direct geometrical proof that, during the period in question, the two poles revolved about each other from west to east in a period of about four hundred days, with a radius of about 0″.23. If these observed coordinates be laid down upon a chart, the points fall into a nearly closed figure, somewhat elongated; approximating to an ellipse with a major axis of about 0″.55, inclined about 45° to the line of reference, and a minor axis of about 0″.30. Now theory indicates a circular motion for the Eulerian term. Assuming that the 428^d-term is the Eulerian one in a modified form, we may plausibly refer to the annual term alone the above observed deviation from circular, or rather epicyclical, motion of the two terms combined. If we therefore compute, by means of equation (52), for the first term,

$$x_1 = 0''.16\sin(t-T_1)\,0^\circ.85, \qquad y_1 = 0''.16\cos(t-T_1)\,0^\circ.85$$

where $T_1 = 241\,1790 + 424\,E$, and subtract them from the above observed values of x and y, we have the observed coordinates of the annual term in the last two columns below.

t	x_1	y_1	x_2	y_2
	″	″	″	″
241 1900	+0.160	−0.010	+0.052	+0.008
1950	+ .111	− .115	− .028	− .082
2000	+ .004	− .160	− .074	− .122
2050	− .106	− .127	− .091	− .057
2100	− .160	− .018	− .002	+ .008
2150	− .129	+ .091	+ .088	+ .081
2200	− .032	+ .157	+ .167	+ .085
2250	+ .082	+ .136	+ .131	− .002
241 2300	+0.154	+0.046	−0.037	−0.049

If the values of x_2 and y_2 be charted, we have a very eccentric ellipse with a major axis of 0″.32, lying in the line 53°–233°, and a minor axis of about 0″.10; the period being manifestly about a year, and the motion being from west to east. The angular velocity seems to stand in some inverse relation to the radius.

Whether the departure from circular motion in the annual term, thus indicated by these observations, is real or merely the result of accidental or systematic error in the observations, it would be of course premature to say. If it be confirmed by future observation, it is perhaps possible that the curious inequalities developed in *A.J.* 322 may be the result of an apsidal motion, of long period, of such an ellipse. At least it seems worth while to bear in mind such a possible geometrical interpretation of the phenomena, in future investigations of the subject.

Strafford, Vt., 1894 *July* 20.

ON THE VARIABLE STAR 6984 *U AQUILAE*,

BY EDWIN F. SAWYER.

In no. 147 of the *Astr. Jour.*, I announced the variability of this star, and in no. 155 I published provisional elements, based on the few observations obtained from 1886 September 21 to December 20. Since then, owing to the press of other astronomical work on my leisure time, no attempt has been made to improve on these elements. The observations, however, were continued, with occasional interruptions, during the years 1886, 1887, 1888, 1889 and 1893, and I now publish the results from a discussion of the 159 observations obtained. All the observations have been brought to bear in the formation of a mean light-curve, using the period $7^{d}.02645$ found by Mr. **Yendell** from his observations and the few already published by me. A comparison of my observations with Mr. **Yendell**'s elements, given in the column O−C below, indicates a correction of $-0^{d}.00106$ to the period, and of $-0^{d}.30$ to the epoch of maximum.

OBSERVED MAXIMA.

E	Boston M.T.	Wt.	O−C
0	1886 Sept. 19.218	1	$-0^{d}.718$
4	Oct. 17.567	1	− .475
5	24.507	1	− .561
6	31.715	1	− .379
7	Nov. 7.628	2	− .493
8	14.493	2	− .654
9	21.709	2	− .465
10	29.650	1	+ .450
12	Dec. 12.777	1	− .476
13	19.451	1	− .829
35	1887 May 23.785	1	− .077
38	June 13.911	3	− .030
40	27.702	3	− .292
41	July 5.350	1	+ .330
42	11.419	2	− .966
43	18.808	2	− .265
44	25.901	1	− .109
46	Aug. 8.888	1	− .265
47	15.941	2	− .238
51	Sept. 13.001	2	− .284
52	20.304	1	− .007
54	Oct. 4.769	1	+ .405
55	11.009	2	− .382
56	18.241	1	− .176
58	31.520	3	−0.950
59	1887 Nov. 8.027	2	$-0^{d}.470$
60	16.018	2	+ .495
61	22.250	1	− .299
90	1888 June 13.426	1	+ .110
94	July 11.293	2	− .129
97	Aug. 1.562	2	+ .060
101	29.376	2	− .231
102	Sept. 5.375	1	− .259
105	26.422	3	− .291
106	Oct. 3.333	1	− .406
109	24.600	2	− .219
110	31.604	2	− .241
111	Nov. 7.517	1	− .355
143	1889 June 20.423	1	− .297
147	July 18.388	1	− .436
148	25.293	2	− .557
152	Aug. 22.340	1	− .616
362	1893 Sept. 5.936	1	− .575
363	12.711	2	− .726
367	Oct. 11.163	3	−0.480

OBSERVED MINIMA.

E	Boston M.T.	Wt.	O−C
5	1886 Oct. 22.602	3	$-0^{d}.346$
7	Nov. 5.868	4	− .133
8	12.934	1	− .093
9	19.947	2	− .107
10	27.208	3	+ .128
11	Dec. 4.323	2	+ .227
13	18.755	1	+ .595
38	1887 June 11.725	2	− .096
40	25.792	1	− .082
42	July 9.296	1	− .631
46	Aug. 7.107	1	+ .074
47	14.052	2	− .007
48	20.770	1	− .315
49	27.340	1	− .771
50	Sept. 4.175	2	+ .038
51	10.675	3	− .490
52	17.929	4	− .262
55	Oct. 9.482	2	+ .211
56	15.723	2	− .574
58	29.527	1	− .823
59	Nov. 6.192	1	−0.185
60	12.250	1	−1.153
61	20.062	1	−0.367
90	1888 June 10.491	2	−0.705

E	Boston M.T.	Wt.	O—C
			d
93	1888 July 1.659	1	−0.615
94	8.677	2	− .625
95	16.333	1	+ .005
97	30.403	1	+ .023
98	Aug. 6.125	1	− .281
99	13 205	3	− .228
101	26.951	3	− .536
102	Sept. 3.523	1	+ .009
105	24.281	1	− .312
106	30.990	2	− .629
107	Oct. 8.292	1	− .353
110	30.250	1	+ .525
111	Nov. 5.239	2	− .513
144	1889 June 25.019	1	−0.607
145	1889 July 2.021	1	−0.631
151	Aug. 13.233	1	−0.577
153	27.032	2	−0.330
156	Sept. 16.586	1	−1.354
157	24.368	1	−0.598
362	1893 Sept. 3.618	2	− .772
363	10.668	3	− .749
364	17.704	1	− .739
365	25.882	1	+0.412
366	Oct. 1.234	1	−1.262
367	8.380	3	−1.143
370	29.437	1	−1.165
371	Nov. 6.322	3	−0.307

The comparison-stars and the light-scale are

	α	δ	U.A.	SAWYER	L. Scale.
	h m s	° ′	M	M	
a = 100 (*U.A.*) *Aquilae*	19 52 59	−10 17.0	6.1	6.15	19.5
b = 92 " "	19 47 21	− 8 53.8	6.2	6.25	16.2
c = 80 " "	19 42 9	−11 10.7	6.4	6.35	14.6
d = 60 " "	19 28 45	− 7 43.9	6.7	6.65	11.2
e = 43 " "	19 16 20	− 7 38.2	6.7	6.70	9.0
f = W.B. 280	19 13 19	− 6 51.5		7.10	5.0
g = W.B. 568	19 24 12	— 6 46.2		7.5	0.0

The positions are for the equinox 1875.0.

The characteristics of the light-fluctuations are a slow increase during the first day after minimum, followed by a very rapid increase during the second day, and a nearly uniform and much slower decrease. The average variation during increase is about half a magnitude a day, while the average daily decrease is 0.20 of a magnitude.

The readings of the light-curve give the following

Light Table.

Time from Max.	Steps	M
d		
−2.12	2.8	7.28
2.00	2.9	7.26
1.75	3.2	7.24
−1.50	3.9	7.19
−1.25	5.1	7.09
1.00	6.3	6.97
0.75	8.2	6.78
−0.50	10.5	6.68
−0.25	14.1	6.39
0.00	15.4	6.27
+0.25	15.1	6.29
0.50	14.6	6.32
0.75	13.9	6.40
1.00	13.2	6.47
1.25	12.3	6.56
1.50	11.3	6.66
1.75	10.5	6.68
2.00	9.5	6.69
+2.25	8.6	6.74
+ 2.50	7.7	6.83
2.75	7.0	6.90
3.00	6.4	6.96
3.25	5.7	7.03
3.50	5.1	7.09
3.75	4.4	7.15
4.00	3.7	7.20
4.25	3.2	7.24
4.50	3.0	7.26
4.75	2.8	7.28
+5.00	2.8	7.28

The range of variation is from $6^{M}.27$ to $7^{M}.28$.

The duration of increase is 2.12 days, and that of decrease 4.91 days.

Brighton, 1894 *June* 29.

OBSERVED MAXIMA AND MINIMA OF VARIABLE STARS,

By P. S. YENDELL.

2100. *U Orionis.*

Thirty observations of *U Orionis*, from 1893 Dec. 4 to 1894 March 19, indicate a maximum of $6^{M}.9$, on 1894 Feb. 12.

2279. *T Monocerotis.*

This star was observed during the season, from 1893 Nov. 16 to 1894 April 2, forty-two times. The observations indicate four maxima and four minima, as follows:

Maxima	w	Minima	w
1893 Dec. 24.88	4	1893 Dec. 14.8	3
1894 Jan. 20.20	4	1894 Jan. 8.0	3
Feb. 15.52	2	Feb. 4.0	4
Mar. 16.21	3	Mar. 4.5	4

2676. *U Monocerotis.*

Twenty observations of *U Monocerotis* were obtained, between 1893 Dec. 10 and 1894 April 2. On the first date its light was estimated at $6^{M}.9$; it rose to a bright maximum of $6^{M}.3$ on 1894 Jan. 2, then declined to a bright minimum of $6^{M}.9$ on Feb. 1. This was followed by a maximum of $6^{M}.4$ on Feb. 18, and a minimum of $7^{M}.4$ on Mar. 23. When last seen, April 2, the star had risen to $6^{M}.6$.

4805. *W Virginis.*

W Virginis was observed nineteen times, from 1894 March 4 to June 23. The observations indicate three maxima and three minima, as follows:

Maxima	w	Minima	w
1894 May 1.4	4	1894 April 5.3	2
20.4	2	26.3	2
June 2.5	2	May 9.8	4

4816. *U Virginis.*

This star was first seen on 1894 May 1, when it was apparently near a maximum, its light being estimated at $8^{M}.5$. It remained at about this brightness until May 26, when it began slowly to decline, reaching a light of $8^{M}.9$ on June 21, the date of the last observation. The star was seen on thirteen occasions.

4847. *S Virginis.*

From 1894 Mar. 7 to June 20, *S Virginis* was observed on eighteen evenings. When first seen, it was probably below $11^{M}.5$, being only glimpsed. It rose pretty rapidly to a well-marked maximum of $7^{M}.5$, which appears to have taken place on May 25. When last observed, it had fallen to $8^{M}.2$.

6062. *RR Scorpii.*

The variability of this star was announced from the Harvard College Observatory, *A.N.* 3225.

It was first observed by me on 1894 May 10, its light being then $7^{M}.9$; it rose rapidly to a sharply-marked maximum of $7^{M}.2$, which was passed on May 30. At the last observation, July 3, it had fallen to $7^{M}.8$.

6207. *Z Ophiuchi.*

This star, whose variability was announced from the Harvard College Observatory, in the same paper with 6062, was taken under observation on 1894 April 24; it being then near a maximum, which is very uncertainly indicated by the next observation, on May 7. From this date it has fallen away steadily, having decreased from $7^{M}.5$ to $8^{M}.9$, which was its estimated brightness at the last observation on July 3.

7085. *RT Cygni.*

Of this star I have four observations, widely spaced apart, from 1894 May 10 to July 3; the rise and decline, however, are so distinctly indicated, that a maximum on June 12 indicated by a free curve drawn through the four observations, seems likely to be very near the truth. The greatest brilliancy observed was $7^{M}.3$.

It seems not out of place here to remark that, since the end of February, the weather has been to so large an extent unfit for observing that a very great proportion of the series of observations which I have undertaken since that time have been rendered useless by interruptions, often amounting to weeks. The above apparently meagre results give no indication of the amount of work done.

Dorchester, 1894 *July* 7.

ON THE FORMS OF THE DISKS OF *JUPITER'S* SATELLITES,

By G. W. HOUGH.

In the *Astr. Jour.*, no. 321, Prof. J. M. Schaeberle, of the Lick Observatory, gives his results on the shape of the disk of the first satellite near elongation. He found from several estimations, occupying an interval of $5^{h}\ 40^{m}$, that the disk had a constant ellipticity, and that the diameters were as 1 to 0.83.

Prof. W. H. Pickering, at Arequipa, from an extended study, found a regular periodic change in the ellipticity of the disks of all four satellites. For the third satellite he estimated the difference between the two diameters as $0''.2$, which is equivalent to a maximum ellipticity, 1 to 0.89.

Prof. E. E. Barnard, on the contrary, from a series of observations with the 36-inch, concluded that the disks of all the satellites were circular.

I have observed *Jupiter* systematically since 1879, on more than six hundred nights, with the 18½-inch refractor of the Dearborn Observatory. While my studies have been more particularly confined to the planet itself, yet I have made micrometer-measures of the diameters of the satellites, and have observed numerous transits, occultations, etc. Under good atmospheric conditions I have never suspected that the disks of any of the satellites were elliptical. In most cases, however, negative testimony is of very little value in its bearing on a disputed point, but if the ellipticity attains the magnitude assigned by Prof. Schaeberle, 0.83 to 1.00, it could not fail to be recognized by an experienced observer, who employs sufficient optical power.

In the case of close double stars a want of symmetry in the stellar disk amounting to $0''.2$ may be detected with the 18½-inch, and this quantity is reduced to $0''.1$ for the 36-inch Lick. Now the first satellite subtends an angle of $1''.1$ at mean distance, and it is perfectly feasible to make micrometer-measures of the disks on two or more diameters. If, therefore, the ellipticity is real, and amounts to one-half the quantity assigned by Prof. Schaeberle, one night's work with the micrometer, on any good telescope above 18 inches of aperture, ought to definitely settle the question.

In the publications of the Astronomical Society of the Pacific, no. 17, Prof. A. A. Michelson gives the results of measurement of the diameters of the satellites of *Jupiter* by interference, and also appends the micrometer-measures of four observers, viz.: Engelmann, Struve, Hough and

Burnham. The mean of the five values, together with the mean residuals, are as follows:

Satellite	I	1.07″	±0.04″
"	II	0.95	±0.03
"	III	1.59	±0.15
"	IV	1.39	±0.12

These results show conclusively that the micrometer can be successfully employed, and it seems to me that it is the only proper way to arrive at a result of any value to science.

It is well known to double-star observers, in the case of very close pairs, that one sees the star-disk elongated in a direction depending on the position of the eye. It is possible that the apparent shape of the disks of the satellites of *Jupiter* may be influenced from a like cause.

Dearborn Observatory, Northwestern University, 1894 *June* 30.

ON THE VARIABILITY OF DM. +4°4250.

19h 44m 16s.5. +4° 5′.9 (1855)

By P. S. YENDELL.

The variability of this star was announced from the Harvard College Observatory, *A.N.* 3225, p. 162.

On 1894 May 10 and 27, I looked for the star unsuccessfully, the limit of vision being estimated on these two occasions respectively as 11M.5 and 11M.0. The place was very carefully identified by the neighboring *Durchmusterung* stars.

On the evening of 1894 July 3 the star was seen in the place indicated, and comparisons made; but, having inadvertently omitted to mark on the chart the comparison-stars used, I cannot now identify these, and the only estimate of magnitude that can be given is the eye estimation of about 9M.3. As before, great care was taken in the identification of the star, whose variability I consider to be decisively confirmed by these observations.

Dorchester, 1894 *July* 7.

The above confirmation by Mr. Yendell now permits the definitive notation, 7118 *X Aquilae;* and the star may be removed from the "Unconfirmed List," Table III of the Supplement to Second Catalogue. *A.J.*, 319. — Ed.

OBSERVATIONS OF COMET *b* 1894,

MADE AT THE OBSERVATORY OF THE CATHOLIC UNIVERSITY, WASHINGTON, D.C.,

By Rev. G. M. SEARLE.

1894 Greenwich M.T.		*	No. Comp.	☄ — *		☄'s apparent		log pΔ	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
May 9	14 55 30	1	8	−1 37.88	+ 3 45.8	9 16 35.62	+13 54 23.9	9.591	0.647
10	13 28 12	2	4	−2 3.18	+ 1 34.5	9 23 46.61	+16 15 48.4	9.413	0.565
	14 28 12	2	5	−1 42.83	+ 7 43.7	9 24 6.96	+16 21 57.6	9.550	0.602
June 23	15 3 26	3	4	−0 47.09	+12 57.7	11 51 49.18	+43 2 26.4	9.741	0.264
28	14 26 14	4	4	+2 38.38	+ 4 10.0	12 4 22.76	+43 19 18.5	9.716	0.129
29	14 47 41	4	3	+4 31.31	+ 6 38.7	12 6 15.69	+43 21 47.2	9.743	0.237
30	15 48 25	4	1	+6 28.80	+ 9 3.5	12 8 13.18	+43 24 12.0	9.790	0.470
	15 59 10	5	5	+1 36.33	− 6 43.9	12 8 13.45	+43 23 57.5	9.794	0.502
July 1	14 43 12	5	3	+3 24.19	− 4 42.2	12 10 1.31	+43 25 59.2	9.744	0.240

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	9 18 12.50	+1.00	+13 50 37.1	+1.0	Lalande 18495
2	9 25 48.72	+1.07	+16 14 12.4	+1.5	Weisse-Bessel IX. 496
3	11 55 34.46	+1.81	+42 49 23.3	+5.4	Weisse-Bessel XI. 1048
4	12 1 42.65	+1.73	+43 15 3.2	+5.3	Weisse-Bessel XI. 1183
5	12 6 35.38	+1.74	+43 30 36.2	+5.2	Weisse-Bessel XII. 95

OBSERVATIONS OF COMET *b* 1894,

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

1894 Cincinnati M.T.		*	No. Comp.	☄ — *		☄'s apparent		log $p.\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
May 31	8 37 31	1	8	−1 30.82	+4 33.4	11 1 1.18	+38 38 22.7	9.512	9.886
June 2	9 54 10	2	8	−3 3.29	−0 7.5	11 6 54.60	+39 23 13.5	9.678	0.229
7	9 56 14	3	7	+3 4.85	+2 36.3	11 20 2.35	+40 48 6.9	9.698	0.221
10	12 42 1	4	7	+0 24.28	−3 15.2	11 27 31.46	+41 27 41.8	9.782	0.682
22	9 7 28	5	12	−0 54.65	−5 41.4	11 52 48.02	+42 57 48.1	9.681	0.021
23	9 23 24	5	8	+1 5.25	−1 12.3	11 54 47.90	+43 2 17.2	9.707	0.124
25	9 28 25	6	9	−3 2.87	−4 58.0	11 58 41.56	+43 10 10.3	9.720	0.167
27	9 27 30	6	8	+0 47.25	+1 36.0	12 2 31.65	+43 16 44.3	9.725	0.178
28	9 3 48	7	8	+1 41.95	+1 54.2	12 4 23.64	+43 19 25.3	9.696	0.057
30	9 12 32	8	8	+1 31.90	−6 41.0	12 8 8.98	+43 24 0.3	9.714	0.129
July 2	9 6 56	9	12	−0 14.92	+4 34.7	12 11 51.58	+43 27 43.9	9.713	0.118
6	10 0 37	10	12	+1 11.50	+3 2.4	12 19 12.93	+43 32 14.5	9.775	0.388

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	11 2 30.27	+1.73	+38 33 43.5	+5.8	Lund A.G.Z.; 2 obs.
2	11 9 56.12	+1.77	+39 23 15.3	+5.7	Lund A.G.Z.; 2 obs.
3	11 16 55.71	+1.79	+40 45 24.7	+5.9	Rad. 1, 2673; Paris 13882
4	11 27 5.36	+1.82	+41 30 51.2	+5.8	Eq. comp. with Bonn VI, +41°2199 and +41°2203
5	11 53 40.85	+1.82 +1.80	+43 3 24.1	+5.4	Bonn VI, +43°2172
6	12 1 42.62	+1.81 +1.78	+43 15 3.0	+5.3	W.B. XI, 1183
7	12 2 36.94	+1.75	+43 17 25.7	+5.4	Eq. comp. with last
8	12 6 35.33	+1.75	+43 30 36.0	+5.3	W.B. XII, 95
9	12 12 4.75	+1.75	+43 23 4.2	+5.0	W.B. XII, 198
10	12 17 59.70	+1.73	+43 29 7.5	+4.6	Bonn VI, +43°2215

ORBITS OF 85 *PEGASI* (β 733),

BY J. M. SCHAEBERLE.

In *A.N.* 3145 Prof. VON GLASENAPP published an orbit of 85 *Pegasi*, based upon all the observations from 1878 to 1892, inclusive. While he represents the data employed with surprising accuracy, some recent observations by myself show that his orbit is much more in error than my own published in 1888 (*A.J.* 185 and 246). I was led to make these observations on account of the great difference between our theoretical positions. At the present time Prof. v. GLASENAPP's computed position-angle is more than 80° greater than that given by my ephemeris.

The residuals in position-angle and distance, found by subtracting the ephemeris-positions from my observed results for 1893 and 1894, are tabulated below for both orbits.

Date	VON GLASENAPP Period 17.5		SCHAEBERLE Period 22.3	
	°	″	°	″
1893.65	−38.1	+0.31	+12.6	+0.10
1894.53	−63.1	+0.44	+17.7	+0.17

As these figures indicate that my orbit is only slightly in error, I defer correcting the elements until the component has made a complete revolution about its primary.

Lick Observatory, 1894 *July* 13.

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THE ORBITS OF DOUBLE STARS,

By A. HALL.

In whatever parts of space the motions of a double star may take place the observer sees these motions projected on a plane perpendicular to the line of sight. Hence the problem of determining the orbit of a double star is naturally divided into two parts: first, the determination of the apparent orbit, and secondly the determination of the real orbit. The apparent orbit is that which is based directly on the observations, and it is the foundation of the whole theory of the motions of these stars. We consider this orbit first.

The Apparent Orbit.

The observations are referred to the principal star by means of angles of position and distances. The angles are counted from the north point toward the following side, and through the whole circle. Denoting this angle by p, and the distance by s, we have in the plane of the apparent orbit,

$$x = s \cos p\,; \qquad y = s \sin p$$

About seventy years have elapsed since accurate measures of double stars were begun, and very few stars have been observed long enough to give a good determination of an orbit. From the few orbits that are known we may infer that double stars move in ellipses, and that the radius vector, or distance, describes areas proportional to the time. It is worth while to notice at the outset the uncertainty arising from errors of observation. The stars are always seen on the surface of a cylinder, generally of very small diameter, and errors of a quarter of a second of arc, or even of a tenth of a second, are relatively so important that the computed results are doubtful. There appears to be no way of overcoming this difficulty except by waiting for the stars to describe greater arcs, which will contain more of the theory of their motions. At present this uncertainty is so great that it is not worth while to spend much labor in elaborate computations from exact formulas. A simple graphical construction is generally sufficient. In most of the known motions of double stars, where only a half or two-thirds of a revolution has been described, the observations can be represented by formulas containing the first and second powers of the time: thus,

$$x = A + Bt + Ct^2\,; \quad y = A' + B't + C't^2$$

These are simple interpolation formulas and no law of force is assumed between the stars, but they represent the observations well, and ephemerides may be computed from them. Such a result shows within what uncertain limits observations confine theory. If the apparent orbit be plotted on a large scale the elements can be measured from this plot. In most cases this is sufficient, and the next step is to pass to the real orbit. Such a procedure requires an assumption concerning the law of force which governs the motions of the stars. The most probable assumption we can make is that the Newtonian law of attraction, which has been so fully tested in our solar system, is also the law of force between the stars. This being the case the principal star is at the focus of the real orbit. But before leaving the apparent motion of the star let us examine it in a general way, such as might be necessary in the case of a well known orbit.

The origin of coordinates being at the principal star, which is not at the focus, the general equation of the ellipse is,

$$F = ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0 \tag{1}$$

This equation contains five independent constants which are to be found from the observed values of x and y, given above. Each observation, or each normal, will furnish values of x and y, and these being substituted in (1) will give an equation of condition. These equations can be weighted and solved by least squares. The five constants having been found in this way the elements of the apparent ellipse can be expressed in known terms. In this work the discriminant of equation (1) frequently occurs, and we denote it by Δ. Thus

$$\Delta = abc + 2fgh - af^2 - bg^2 - ch^2 = \begin{vmatrix} a, & h, & g \\ h, & b, & f \\ g, & f, & c \end{vmatrix}$$

Some of the minors of this determinant are useful, and may be designated as follows:

$$C = ab - h^2; \quad F = gh - af; \quad G = hf - bg$$

The coordinates of the center are given by the equations,

$$x_0 = \frac{G}{C}\,; \quad y_0 = \frac{F}{C}$$

If now we take the center as origin the equation of the ellipse becomes

$$ax^2 + 2hxy + by^2 + c' = 0$$

where

$$c' = \frac{\Delta}{C}$$

If we turn the axes so as to get rid of the term in xy the equation of the curve takes the form,

$$a'x^2 + b'y^2 + c' = 0$$

Let us put

$$R^2 = 4h^2 + (a-b)^2$$

then

$$a' = \tfrac{1}{2}(a+b-R); \quad b' = \tfrac{1}{2}(a+b+R)$$

The equation can be changed to the normal form of an equation to the ellipse when referred to its center and principal axes by substituting the values of a', b', c', and dividing. Thus

$$\frac{x^2}{\cfrac{-2\Delta}{C\,(a+b-R)}} + \frac{y^2}{\cfrac{-2\Delta}{C\,(a+b+R)}} = 1$$

or

$$\frac{x^2}{\alpha^2} + \frac{y^2}{\beta^2} = 1$$

where α^2 and β^2 are the roots of the equation

$$z^2 + \frac{(a+b)\Delta}{C^2}.z + \frac{\Delta^2}{C^3} = 0$$

The principal axes of the apparent ellipse will be given, and the excentricity will follow. In the first system of coordinates, the axis of x is directed toward the north point. The position of the new will be given by adding the angle θ through which the axes are turned in the transformation. In this case

$$\tan 2\theta = \frac{2h}{a-b}$$

As the plane of the apparent orbit is perpendicular to the line of sight all the elements of this orbit are known.

In the apparent orbit the principal star is not at the focus. The observations however indicate that this star is the center of force, and it is an interesting question what laws of force will produce the observed phenomena. VILLARCEAU has investigated this problem in the *Conn. des Temps* for 1852. If we take the principal star as the origin we have (1) as the equation of the apparent orbit. The conditions that the force is central, and the areas proportional to the time, give,

$$y\,\frac{dx}{dt} - x\,\frac{dy}{dt} = 2k$$

k being a constant. If φ be the constant force, and r the radius-vector, the equations of motion are

$$\frac{d^2x}{dt^2} + \varphi.\frac{x}{r} = 0 \qquad \frac{d^2y}{dt^2} + \varphi.\frac{y}{r} = 0$$

The first and second derivatives of (1) are

$$\frac{\delta F}{\delta x}.\frac{dx}{dt} + \frac{\delta F}{\delta y}.\frac{dy}{dt} = 0$$

$$\frac{\delta F}{\delta x}.\frac{d^2x}{dt^2} + \frac{\delta F}{dy}.\frac{d^2y}{dt^2} + \frac{\delta^2 F}{\delta x^2}.\frac{dx^2}{dt^2} + \frac{\delta^2 F}{\delta y^2}.\frac{dy^2}{dt^2} + 2\,\frac{\delta^2 F}{\delta x\,\delta y}.\frac{dx}{dt}.\frac{dy}{dt} = 0$$

The above integral of areas, and the first derivative of F, give

$$\frac{dx}{dt} = \frac{2k}{U}.\frac{\delta F}{\delta y}; \qquad \frac{dy}{dt} = -\,\frac{2k}{U}.\frac{\delta F}{\delta x}$$

where

$$U = x\,\frac{\delta F}{\delta x} + y\,\frac{\delta F}{\delta y}$$

By means of these values and the equations of motion we can eliminate $\frac{dx}{dt}, \frac{dy}{dt}, \frac{d^2x}{dt^2}, \frac{d^2y}{dt^2}$ from the second derivative, and find

$$-\frac{\varphi}{r}.\left(x\frac{\delta F}{\delta x} + y\frac{\delta F}{\delta y}\right)$$
$$+\frac{4k^2}{U^2}.\left(\frac{\delta F^2}{\delta x^2}.\frac{\delta^2 F}{\delta y^2} + \frac{\delta F^2}{\delta y^2}.\frac{\delta^2 F}{\delta x^2} - 2\,\frac{\delta^2 F}{\delta x\,\delta y}.\frac{\delta F}{\delta x}.\frac{\delta F}{\delta y}\right) = 0$$

We have

$$\frac{\delta F}{\delta x} = 2ax + 2hy + 2g; \quad \frac{\delta F}{\delta y} = 2by + 2hx + 2f$$

$$\frac{\delta^2 F}{\delta x^2} = 2a; \quad \frac{\delta^2 F}{\delta y^2} = 2b; \quad \frac{\delta^2 F}{\delta x\,\delta y} = 2h$$

With these values the term in the last parenthesis becomes

$$(ab-h^2)\,(ax^2+by^2+2hxy+2gx+2fy) + af^2 + bg^2 - 2fgh$$

or

$$af^2 + bg^2 + ch^2 - abc - 2fgh = -\Delta$$

multiplied by the numerical factor 8. Hence substituting $\frac{\Delta}{32}$ we may write

$$\varphi = -\frac{k^2}{U^3}.\Delta r \qquad (2)$$

and the law of force depends on the function U. We have

$$U = 2\,(ax^2+2hxy+by^2+gx+fy)$$

Comparing with (1) we find the values

$$U_1 = ax^2 + 2hxy + by^2 - c$$
$$U_2 = -2\,(gx+fy+c)$$

which appear to be the simplest forms, but other forms may be found. If we transform U_2 to polar coordinates

$$x = r\cos v, \quad y = r\sin v$$

we have

$$\frac{U_2}{r} = -\,2\left(g\cos v + f\sin v + \frac{c}{r}\right) = -\,U'$$

and by (2)

$$\varphi = \frac{k^2}{U'^3}\cdot\frac{\Delta}{r^2}$$

For the Newtonian law of attraction we must have $U' =$ constant.

or $$U_2 = r.\ \text{const.} = rn$$

and $$r = \frac{2c}{g\cos v + f\sin v + n}$$

which is the equation of a conic. If we assume that U_1 and U_2 are constants, the form of U_1 gives a conic section, the force being at the center and

$$\varphi = r\,.\,\text{const.}$$

This is a well known form of elliptic motion in which the periodic time is independent of the distance. For the case of U_2 a constant the orbit is a right line, and as we have

$$a = 0\,,\quad b = 0\,,\quad h = 0\,,\quad \Delta = 0\,,$$

the value of φ is zero.

We have therefore an indefinite number of laws of force under which the apparent orbit could be described. A good proof of any law is difficult, since we do not see the real orbit, and the yearly change in the position of the observer is so small that it furnishes no means of investigation. Savary pointed out that the equation of light might be used for determining the size of the orbit, but this does not seem practicable at present. Our only method is to continue the observations of these stars with the best means at hand, and wait for time to show the true laws of motion. It is interesting to consider some of the phenomena which observations have already disclosed. We notice,

(*a*). The variable stars and the theories proposed to explain their variations of light.

(*b*). The great diversity of the stars in color and spectra.

(*c*). The presence of dark bodies in some of the stellar systems comparable in mass to the stars themselves.

(*d*). The complication of the mechanical problem when there are several nearly equal centers of force.

(*e*). The very great velocities of some of the stars, which it is difficult to understand in a stable system of bodies.

(*f*). The recent determinations of the motions of stars in the line of sight, and the discovery in this way of very close double stars.

The Real Orbit.

As the Newtonian law of gravitation has satisfied observations for a hundred years in our solar system, it is natural to extend this law to stellar systems; and in order to pass to the real orbit of the stars in space we assume this law. In this case the principal star will be at the focus of the real ellipse. If a good graphical construction of the apparent orbit be made, we can pass to the real orbit by means of the elegant method given by Thiele, *A.N.* LII. Let S be the place of the principal star in the apparent orbit, and draw the elliptical chord ASB as often as we please. Measure the segments AS, BS, for each chord, and compute the harmonic mean, SC, for every pair of segments by the formula

$$\frac{2}{SC} = \frac{1}{SA} + \frac{1}{SB}$$

and lay off SC on the chord from S in both directions. The points C lie on an ellipse whose center is S. The major axis of this auxiliary ellipse will be the parameter of the real ellipse, and the direction of the major axis of the auxiliary ellipse is the line of nodes. The ratio of the principal axes of the auxiliary ellipse will give the inclination of the real orbit to the apparent orbit. This forms an easy graphical solution, and it is sufficiently accurate for most cases. The principle on which Thiele's construction depends is the following: — If in the plane of the real orbit a focal chord be drawn, the harmonic mean of the segments of this chord made by the focal point is the semiparameter. This follows from the equation of the ellipse

$$r = \frac{p}{1 + e\cos v}$$

One of the segments will be

$$r_1 = \frac{p}{1 + e\cos v}$$

and the other

$$r_2 = \frac{p}{1 - e\cos v}$$

Hence

$$\frac{2}{p} = \frac{1}{r_1} + \frac{1}{r_2}$$

or p is the harmonic mean of r_1 and r_2. If therefore we draw a circle in the plane of the real orbit with the focus as center, and with radius p, the harmonic mean of all the segments of focal chords will lie on the circumference of this circle. When this circle is projected on the plane of the apparent orbit it becomes Thiele's auxiliary ellipse.

Since the centers of the real and apparent ellipses coincide, and in the real ellipse the center, focus, and periastron lie on a right line, these points will also lie on a right line in the projected, or apparent ellipse; so that if a right line be drawn through the center of the apparent orbit and the principal star, and extended to meet the periphery of the ellipse we shall have the points of periastron and apastron. Call this diameter of the apparent orbit $2a$, and its conjugate 2β. The excentricity of the real orbit is not altered by projection, and is given by the distance from the center to the principal star in the apparent orbit, compared with the distance from the center to the periphery. Denote the angle from the north point to the intersection of the two orbits by Ω, and the angles from the same point to the ends of the axes of α and β by A and B. Imagine a plane drawn through the extremity of the axis of α, through the extremity of the major axis of the real orbit, and perpendicular to the line of nodes. If $2a$ and $2b$ be the principal axes of the real ellipse, a will be the hypothenuse of a right triangle formed by α itself, the trace of the plane on the real orbit, and the part cut off on the line of nodes. Hence we have

$$\alpha^2 \cos^2(A-\Omega) + \alpha^2 \sin^2(A-\Omega) \sec^2 i = a^2$$
$$\beta^2 \cos^2(B-\Omega) + \beta^2 \sin^2(B-\Omega) \sec^2 i = b^2$$

where i is the inclination of the orbit planes. The square of the chord joining the extremities of the axes is

$$[\alpha \cos(A-\Omega) - \beta \cos(B-\Omega)]^2 + [\alpha \sin(A-\Omega) - \beta \sin(B-\Omega)]^2 \sec^2 i = a^2 + b^2$$

Subtracting the sum of the first equations we have

$$\sec^2 i = -\operatorname{cotg}(A-\Omega) \operatorname{cotg}(B-\Omega)$$

Dividing the first equations, and substituting the value of $\sec^2 i$, the result is

$$\frac{\alpha^2 b^2}{a^2 \beta^2} = -\frac{\sin 2(B-\Omega)}{\sin 2(A-\Omega)}$$

Since the ratio $\frac{b^2}{a^2} = 1-e^2$, e being the excentricity, and α and β are known from the apparent orbit, the last equation gives Ω. The condition that

$$\cos^2 i = \tan(A-\Omega) \tan(\Omega-B)$$

must be positive and less than unity, limits the value of Ω to two arcs differing 180° from each other. Hence the ascending and descending nodes cannot be separated, and this condition exists in the nature of the question. These formulas may be used for geometrical construction or for computation. Other formulas can be found by using the polar equation of the ellipse with origin at the center. Since the centers of the two orbits coincide, and the point of periastron on the apparent orbit is known, we shall have by the polar equation the distance from the center to this point, which is the projection of the semi-major axis of the real orbit. The excentricity being known the ratio of the real axes, $2a$ and $2b$, is also known; and by comparing the areas of the two ellipses the product is given, thus

$$ab \cos i = \alpha\beta$$

When the stars have been observed through one or more revolutions, and the data are sufficient for an accurate determination of the orbit, we may need a more general method of passing to the real orbit. Such a method has been given by Prof. Kowalsky. For clearness we write equation (1) again with a different notation:

$$Ax^2 + 2Hxy + By^2 + 2Gx + 2Fy + 1 = 0 \qquad (3)$$

The five independent constants which determine the apparent orbit will be found by substituting the observed values of x and y, and it is required to express the elements of the real orbit in terms of these constants. As the line of nodes is not altered by projection it offers a means of comparing the equations of the two orbits. Since the axis of x in the apparent orbit is directed to the north point we have to turn this axis through the angle Ω to the line of nodes, and then the axis of y through the angle i into the plane of the real orbit. We have to substitute therefore in equation (3)

for x, the value $x \cos\Omega - y \sin\Omega \cos i$
for y, " " $x \sin\Omega + y \cos\Omega \cos i$

This gives

$$\begin{aligned} &A(x\cos\Omega - y\sin\Omega\cos i)^2 \\ &\quad + 2H(x\cos\Omega - y\sin\Omega\cos i)(x\sin\Omega + y\cos\Omega\cos i) \\ &+ B(x\sin\Omega + y\cos\Omega\cos i)^2 + 2G(x\cos\Omega - y\sin\Omega\cos i) \\ &\quad + 2F(x\sin\Omega + y\cos\Omega\cos i) + 1 = 0 \end{aligned}$$

The equation of the real orbit referred to the focus is

$$\frac{(x+ae)^2}{a^2} + \frac{y^2}{b^2} - 1 = 0$$

Let λ be the angle from the node to the periastron on the real orbit, and turning the axis of x back to the line of nodes we have the new coordinates

$$x\cos\lambda + y\sin\lambda$$
$$-x\sin\lambda + y\cos\lambda$$

and the preceding equation referred to the line of nodes is

$$\frac{(x\cos\lambda + y\sin\lambda + ae)^2}{a^2} + \frac{(-x\sin\lambda + y\cos\lambda)^2}{b^2} - 1 = 0$$

This equation multiplied by a constant factor must give the coefficients of the variables equal to those in the equation deduced from the apparent orbit. If ε be the multiplier we have

$$\varepsilon\left(\frac{\cos^2\lambda}{a^2} + \frac{\sin^2\lambda}{b^2}\right) = A\cos^2\Omega + B\sin^2\Omega + H\sin 2\Omega \qquad (\alpha)$$

$$\varepsilon\left(\frac{\sin^2\lambda}{a^2} + \frac{\cos^2\lambda}{b^2}\right) = (A\sin^2\Omega + B\cos^2\Omega - H\sin 2\Omega)\cos^2 i \qquad (\beta)$$

$$\varepsilon\left(\frac{1}{a^2} - \frac{1}{b^2}\right)\sin 2\lambda = (-A\sin 2\Omega + B\sin 2\Omega + 2H\cos 2\Omega)\cos i \qquad (\gamma)$$

$$\varepsilon \, . \, \frac{e\cos\lambda}{a} = G\cos\Omega + F\sin\Omega \qquad (\delta)$$

$$\varepsilon \, . \, \frac{e\sin\lambda}{a} = (-G\sin\Omega + F\cos\Omega)\cos i \qquad (\varepsilon)$$

$$\varepsilon \, . \, (e^2-1) = +1$$

The last equation gives $\varepsilon = -\frac{1}{1-e^2}$ and if we denote by p the semi-parameter of the orbit,

$$\frac{\varepsilon e}{a} = -\frac{e}{p}; \qquad \varepsilon \,.\left(\frac{1}{a^2} - \frac{1}{b^2}\right) = \frac{e^2}{p^2}$$

The equations (δ) and (ε) give

$$e \sin\lambda = -p\,.(F\cos\Omega - G\sin\Omega)\cos i$$
$$e \cos\lambda = -p\,.(F\sin\Omega + G\cos\Omega)$$

From the multiplication of the same equations

$$\frac{e^2}{p^2}\sin 2\lambda = (F^2\sin 2\Omega - G^2\sin 2\Omega + 2FG\cos 2\Omega)\cos i$$

From (γ), $\frac{e^2}{p^2}\sin 2\lambda = (-A\sin 2\Omega + B\sin 2\Omega$
$+ 2H\cos 2\Omega)\cos i$

These equations give

$$(\zeta) \qquad (F^2 - G^2 + A - B)\sin 2\Omega + 2(FG - H)\cos 2\Omega = 0$$

If we subtract (β) from (α) we have a value of $\frac{e^2}{p^2}\cos 2\lambda$, and the difference of the squares of $e\cos\lambda$, and $e\sin\lambda$ furnishes another value. Equating these the result is

$$\cos^2 i = \frac{(F^2 - B)\sin^2\Omega + (G^2 - A)\cos^2\Omega + (FG - H)\sin 2\Omega}{(F^2 - B)\cos^2\Omega + (G^2 - A)\sin^2\Omega - (FG - H)\sin 2\Omega}$$

The forms of the numerator and denominator show that if we put $\cos^2 i = \frac{P}{Q}$ and hence $\tan^2 i = \frac{Q-P}{P} = \frac{P+Q}{P} - 2$, we shall have

$$\tan^2 i = \frac{F^2 + G^2 - (A+B)}{P} - 2$$

Equation (β) gives

$$\frac{e^2}{p^2}\sin^2\lambda - \frac{1}{p^2} = (A\sin^2\Omega + B\cos^2\Omega - H\sin 2\Omega)\cos^2 i$$

and (ε), $\frac{e^2}{p^2}\sin^2\lambda = (F^2\cos^2\Omega + G^2\sin^2\Omega - FG\sin 2\Omega)\cos^2 i$

and hence

$$\frac{1}{p^2} = [(F^2 - B)\cos^2\Omega + (G^2 - A)\sin^2\Omega - (FG - H)\sin^2\Omega]\cos^2 i$$

By comparing with the expression for $\cos^2 i$ we find $\frac{1}{p^2} = P$, and hence

$$(\eta) \qquad \frac{2}{p^2} + \frac{\tan^2 i}{p^2} = F^2 + G^2 - (A+B)$$

From the value of $\frac{1}{p^2}$ it follows that

$$\frac{2}{p^2} = F^2 + G^2 - (A+B) - (F^2 - B)\cos 2\Omega$$
$$+ (G^2 - A)\cos 2\Omega + 2(FG - H)\sin 2\Omega$$

and from (η)

$$(\theta) \quad \frac{\tan^2 i}{p^2} = (F^2 - G^2 + A - B)\cos 2\Omega - 2(FG - H)\sin 2\Omega$$

By the combination of equations (ζ) and (θ) we shall have

$$\frac{\tan^2 i}{p^2}\sin 2\Omega = -2(FG - H)$$
$$\frac{\tan^2 i}{p^2}\cos 2\Omega = F^2 - G^2 + A - B$$

Arranging the formulas for computation, **Kowalsky**'s system is

$$\frac{\tan^2 i}{p^2}\sin 2\Omega = -2(FG - H)$$
$$\frac{\tan^2 i}{p^2}\cos 2\Omega = F^2 - G^2 + A - B$$
$$\frac{2}{p^2} + \frac{\tan^2 i}{p^2} = F^2 + G^2 - (A+B) \qquad (A)$$
$$e\sin\lambda = -p(F\cos\Omega - G\sin\Omega)\cos i$$
$$e\cos\lambda = -p(F\sin\Omega + G\cos\Omega)$$
$$a = \frac{p}{1-e^2}$$

These elegant and convenient formulas were given by Professsor **Kowalsky** in 1873, but I have not been able to find his work. They were published by Professor **Glasenapp** in the *Monthly Notices*, Vol. 19. p. 278. Convenient formulas have been given by Professor **Seeliger**, and published by Dr. **Schorr**.

In this connection Professor **Glasenapp** has proposed a simple and easy method of determining the coefficients of equation (3), in the case where a good drawing of the apparent orbit has been made and it is not thought worth while to find these coefficients by the method of least squares. He puts $y = 0$, and the roots of the quadratic

$$Ax^2 + 2Gx + 1 = 0$$

are the values of x at the points where the orbit cuts the axis of x. If these values are measured, and called x_1 and x_2, the theory of equations gives

$$A = \frac{1}{x_1 x_2}; \qquad G = -\frac{x_1 + x_2}{2x_1 x_2}$$

In the same way by putting $x = 0$

$$B = \frac{1}{y_1 y_2}; \qquad F = -\frac{y_1 + y_2}{2y_1 y_2}$$

To find H a fifth point must be taken, such that xy has a great value:

$$H = -\frac{Ax^2 + By^2 + 2Gx + 2Fy + 1}{2xy}$$

Several points may be used for computing H and the mean value adopted.

After elements have been found by formulas (A) we have to compute the position of the star in the real ellipse at the time of observation, and thence find the mean motion and the time of periastron. Let the true, the excentric and the mean anomalies be v, E, and M. If now p be an observed angle of position, the right spherical triangle between the node and the arcs on the apparent and real orbits gives

$$\tan(v + \lambda) = \frac{\tan(p - \Omega)}{\cos i}$$

In the plane of the real orbit we have the known formulas

$$\tan \tfrac{1}{2} E = \left(\frac{1-e}{1+e}\right)^{\frac{1}{2}} \tan \tfrac{1}{2} v$$

$$M = E - e \sin E$$

Then $$M = n\,(t-T)$$

where n is the mean motion in a tropical year, and T is the time of periastron. n will be found from values of M at distant epochs, and then T will follow.

After the orbit has been found we shall have the inverse problem of computing the angle of position and the distance of the stars at a given time. For this time the mean anomaly will be known, and the excentric anomaly will be found from the equation

$$E = M + e \sin E$$

This equation can be solved by trial, or by the help of tables like those of **Astrand**; from E we compute the true anomaly. The angle of position and the distance follow from the equations

$$\begin{aligned} \tan\,(p-\Omega) &= \tan\,(v+\lambda) \cos i \\ s &= a(1-e \cos E)\,.\,\frac{\cos\,(v+\lambda)}{\cos\,(p-\Omega)} \qquad (4) \end{aligned}$$

If preferred the angle of position and the distance may be computed by a method similar to that of **Gauss** for a planet. As given by **Encke** the necessary formulas are as follows:

$$\begin{aligned} \sin u \sin U &= \cos \Omega \\ \sin u \cos U &= -\sin \Omega \cos i \\ a \sin u \sin\,(U+\lambda) &= q \sin V \\ b \sin u \cos\,(U+\lambda) &= q \cos V \\ -e\, q \sin V &= k \end{aligned} \qquad \begin{aligned} \sin u' \sin U' &= \sin \Omega \\ \sin u' \cos U' &= \cos \Omega \cos i \\ a \sin u' \sin\,(U'+\lambda) &= q' \sin V' \\ b \sin u' \cos(U'+\lambda) &= q' \cos V' \\ -e\, q' \sin V' &= k' \end{aligned}$$

$$\begin{aligned} s \sin p &= q' \sin\,(E+V') + k' \\ s \cos p &= q \sin\,(E+V) + k \end{aligned}$$

It is customary after a comparison with the observations and finding the residuals to compute equations of condition and correct the orbit by the method of least squares. On account of the great uncertainty of most of the orbits this appears to be generally a useless labor, but no doubt the practice will be continued, and the desire to obtain the best result is a good one. The coefficients in the equations of condition are the partial derivatives of the angle and distance with respect to the elements, and may be found from equations (4). Since the systematic errors of the distance are large it is best to use the angle only. If we put the excentricity $= \sin \varphi$, the form of the equation of condition is

$$a\Delta\Omega + b\Delta i + c\Delta\lambda + d\Delta\varphi + \varepsilon\Delta M_0 + f\Delta n + \mathrm{C}-\mathrm{O} = 0$$

The coefficients have the values,

$$a = +1 \qquad d = \frac{(2-e\cos E-e^2)\sin E}{(1-e\cos E)^2}\,.\,c$$

$$b = -\sin i \tan(v+\lambda) \cos^2(p-\Omega) \qquad \varepsilon = \frac{\cos\varphi}{(1-e\cos E)^2}\,.\,c$$

$$c = \frac{\cos^2(p-\Omega)}{\cos^2(v+\lambda)} \cos i \qquad f = (t-T)\,.\,\varepsilon$$

In such equations the coefficients should be reduced to the same numerical order by the introduction of multipliers, as this will facilitate the solution.

Under the assumed law of attraction we shall have the known equation,

$$a^3 n^2 = m + m'$$

where m and m' are the masses of the stars. The semi-major axis a is expressed in seconds of arc, and in order to give it a definite meaning, and to express the sum of the masses of the stars in terms of the mass of our sun, we must know the distance of the double star, or its parallax. As n is the mean orbital motion of the stars we may write

$$4\pi^2 a^3 = P^2.\,(m+m')$$

P is the period of revolution, the unit of time being a year. If we take the mass of our sun as the unit of mass, and the earth's mean distance from the sun as the unit of length, we have

$$4\pi^2 = 1 + \mu$$

where μ is the mass of the Earth. If we denote by p_1 the annual parallax of the star, then,

$$\frac{a}{p_1} = P^{2/3}\left(\frac{m+m'}{1+\mu}\right)^{1/3}$$

a and p_1 are expressed in seconds of arc. This equation will give the sum of the masses of the stars when the parallax is known. We can not find the ratio of m to m' without further data. By assuming numerical values of $m + m'$, such as 1, 2, &c., we could inversely compute values of the parallax. These values are called hypothetical values.

Orbit of μ' Herculis.

As an application of the preceding formulas the orbit of μ' *Herculis* has been computed. These stars are only of the 10th and 11th magnitudes, and as might be expected the observations are discordant. They were reduced to rectangular coordinates and plotted on a scale of four inches to a second of arc. A curve was drawn through the points, and an orbit was computed by **Glasenapp's** method. It appeared that the distance from the node, or λ, was not well separated from M_0. λ was changed to satisfy some of the better observations and the following elements were found:

$$\begin{array}{rcl} T & = & 1880.43 \\ \Omega & = & 64^\circ.74 \\ \lambda & = & 182.91 \\ i & = & 67.10 \\ e & = & 0.1710 \\ a & = & 1''.356 \\ P & = & 42.53 \text{ years} \end{array} \qquad \left.\begin{array}{l} \\ \\ \\ \end{array}\right\} 1880.0$$

Ten normal positions were then formed from the observed angles, and these elements were compared with them. The results are

Date	p	C — O
	°	
1860.08	66.33	+1.73
1866.06	85.67	+1.32
1868.07	99.90	−0.55
1873.99	193.93	+4.67
1877.67	231.54	+0.52
1881.49	251.78	−0.78
1884.94	278.58	−4.35
1888.17	331.11	−2.47
1890.51	10.79	+3.37
1894.50	38.38	+6.60

The equations of condition are

$$\begin{array}{rrrrrrrcl|rcl}
 & & & & & & & & & & \text{Residuals} & \\
+1.000\,\Delta\Omega & -0.138\,\Delta i & +0.396\,\Delta\lambda & -0.072\,\Delta\varphi & +0.285\,\Delta M_0 & -0.581\,\Delta n & +1^\circ.73 & = & 0. & -0^\circ.06 & = & -0''.001 \\
+1.000 & -0.830 & +0.702 & -0.921 & +0.563 & -0.809 & +1.32 & = & 0. & +1.93 & = & +0.039 \\
+1.000 & -1.107 & +1.092 & -1.788 & +0.943 & -1.165 & -0.55 & = & 0. & +1.00 & = & +0.016 \\
+1.000 & +1.183 & +1.523 & -3.010 & +1.761 & -1.134 & +4.67 & = & 0. & -0.24 & = & -0.003 \\
+1.000 & +0.507 & +0.494 & -0.585 & +0.676 & -0.186 & +0.52 & = & 0. & -2.80 & = & -0.051 \\
+1.000 & -0.257 & +0.415 & +0.203 & +0.591 & +0.063 & -0.78 & = & 0. & -1.54 & = & -0.029 \\
+1.000 & -1.014 & +0.918 & +1.556 & +1.170 & +0.528 & -4.35 & = & 0. & -1.98 & = & -0.027 \\
+1.000 & -0.250 & +2.548 & +5.191 & +2.749 & +2.128 & -2.47 & = & 0. & -0.50 & = & -0.005 \\
+1.000 & +1.161 & +1.690 & +3.240 & +1.616 & +1.629 & +3.37 & = & 0. & +0.35 & = & +0.004 \\
+1.000 & +0.753 & +0.638 & +0.871 & +0.520 & +0.731 & +6.60 & = & 0. & +3.39 & = & +0.080
\end{array}$$

The coefficients show the difficulty of separating $\Delta\lambda$ and ΔM_0. I have therefore united these corrections and taken the mean of their coefficients. The solution gives:

$$\begin{array}{rcl} \Delta\Omega & = & -2^\circ.09 \\ \Delta i & = & -3.28 \\ \Delta(\lambda+M_0) & = & +0.96 \\ \Delta\varphi & = & -0.1024 \\ 10\Delta n & = & +0.8814 \end{array} \qquad \begin{array}{rcl} & \text{New Elements} & \\ T & = & 1880.43 \\ \Omega & = & 62^\circ.65 \\ \lambda & = & 183\ .87 \\ i & = & 63\ .82 \\ e & = & 0\ .16922 \\ a & = & 1''.356 \\ P & = & 42.09 \text{ years} \end{array}$$

ΔM_0 has been put equal zero, and I have retained the value of a found from the plot, because as will be seen from the following table the personal errors in measuring the distance of this star are very great. It is customary to compute a for each observer by means of the second of equations (4), and thence derive a mean value of this element. It is probable that the period is several years greater than the above. In the following table I have compared the observations with the last elements, omitting a few comparisons where there is evidently some mistake, or where the observer has indicated an uncertainty. The angles are reduced to 1880. The formulas for the angle and distance are the following, the constants being expressed in seconds of arc:

$$s \sin p = [0.0916] \sin (E+261^\circ.02) + 0.2065$$
$$s \cos p = [9.9101] \sin (E+313^\circ.91) + 0.0991$$

Date	p	Δp	s	ΔS	No.	Observer	Date	p	Δp	s	ΔS	No.	Observer
	°	°	″	″				°	°	″	″		
1857.50	59.12	+ 0.05	1.818	—0.253	2	Dawes	1869.73	130.83	—12.22	. .	. .	1	Winlock
57.85	71.60	—11.46	1.738	—0.166	1	Secchi	69.73	111.68	+ 6.93	. .	. .	2	Peirce
59.70	60.25	+ 4.97	2.054	—0.477	3	Dawes	71.51	(100.0)	. .	(0.6)	. .	1	Wilson
60.30	67.57	— 0.70	1.64	—0.074	1	Struve	71.51	(100.9)	. .	(0.6)	. .	1	Gledhill
62.82	78.39	— 3.91	1.50	—0.032	1	Struve	71.52	156.74	— 8.19	0.62	—0.024	1	Struve
64.43	77.49	+ 2.70	1.806	—0.493	1	Dawes	73.50	(90.0)	. .	. .	. .	1	Wilson and Seabrooke
64.49	67.40	+13.04	1.7	—0.381	1	Engelmann	73.50	185.46	+ 0.36	0.63	+0.015	1	Struve
64.76	78.69	+ 2.88	1.76	—0.480	1	Winnecke	74.48	202.40	— 2.19	0.755	—0.025	4	Newcomb
65.43*a*	80.44	+ 3.92	1.838	—0.625	1	Knott	74.64	(100.5)	. .	. .	. .	2	Gledhill
65.44	81.93	+ 2.48	1.27	—0.058	5	Dembowski	75.58	215.16	— 2.63	. .	. .	6	Schiaparelli
66.59	86.21	+ 4.40	. .	. .	1	Winlock	75.69	225.87	—12.24	. .	. .	1	Newcomb
66.56	86.21	+ 4.20	. .	. .	1	Searle	75.69*b*	220.59	— 6.96	(1.180)	. .	5	Hall
66.68	89.41	+ 1.76	1.100	—0.029	2	Struve	75.70	217.57	— 3.84	. .	. .	1	Holden
67.59	92.92	+ 4.22	. .	. .	1	Winlock	76.59	223.38	— 2.21	0.720	+0.226	4	Hall
67.58	97.82	— 0.75	. .	. .	3	Searle	76 58	216.03	+ 5.06	0.83	+0.114	4	Dembowski
68.50	97.63	+ 7.16	0.88	—0.027	1	Struve	76.60	228.68	— 7.42	1.012	—0.066	4	Struve
1868.61	106.33	— 0.37	. .	. .	1	Winlock	1877.47*c*	235.98	— 8.59	. .	. .	1	Seabrooke

Date	p	Δp	s	ΔS	No.	Observer	Date	p	Δp	s	ΔS	No.	Observer
	°	°	″	″				°	°	′	″		
1877.59*b*	227.89	+ 0.31	(0.8)	.	5	Schiaparelli	1883.63	274.82	—10.42	. .	. .	5	Schiaparelli
77.59	232.79	— 4.59	0.850	+0.179	2	Hall	83.96	260.62	+ 6.24	0.615	+0.289	7	Engelmann
77.62	229.86	— 1.56	0.925	+0.107	4	Dembowski	84.64	273.40	0.00	0.650	+0.184	3	Hall
77.89	235.62	— 5.42	1.127	—0.075	3	Struve	85.45	269.13	+13.42	1.15	—0.413	1	Holetschek
78.48	234.89	— 1.28	1.05	+0.035	6	Burnham	85.56	288.06	— 4.12	0.610	+0.115	3	Hall
78.50	233.79	— 0.06	0.88	+0.207	1	Hall	85.57	267.13	+16.94	. .	. .	1	Holetschek
79.45	242.70	— 3.65	0.90	+0.221	5	Burnham	86.60	300.16	— 0.75	0.386	+0.244	5	Hall
79.55	239.47	+ 0.13	0.970	+0.151	3	Hall	87.54	318.39	— 1.06	0.49	+0.091	6	Schiaparelli
79.75*c*	(134.75)	. .	. .	. .	11	Seabrooke	87.58	321.52	— 3.35	0.423	+0.157	3	Hall
80.46*c*	(230.23)	. .	(0.7)	. .	5	Schiaparelli	88.47	330.80	+ 5.80	0.63	—0.050	3	Tarrant
80.47	245.90	— 1.33	0.96	+0.163	7	Burnham	88.63	343.33	— 3.55	0.43	+0.153	11	Schiaparelli
80.65	246.28	— 0.73	1.005	+0.114	4	Hall	88.63	341.50	— 1.77	0.388	+0.195	4	Hall
80.78	246.50	— 0.24	1.180	—0.062	3	Frisby	89.51	357.84	— 1.66	0.55	+0.088	4	Burnham
81.41	252.11	— 2.34	0.92	+0.175	5	Burnham	89.65	0.68	— 2.11	0.345	+0.302	4	Hall
81.52	254.14	— 3.77	0.87	+0.220	3	Hough	90.38	9.46	— 0.19	0.66	+0.063	4	Burnham
81.55	249.09	+ 1.42	1.008	+0.082	5	Hall	90.55	13.28	— 2.03	0.512	+0.213	4	Hall
82.52	259.14	— 2.67	0.702	+0.327	4	Hall	91.38	18.57	+ 2.12	0.72	+0.120	3	Burnham
82.53	261.62	— 5.08	0.900	+0.128	3	Hough	91.57	24.89	— 2.31	0.540	+0.318	4	Hall
82.60	266.79	— 9.80	. .	. .	7	Schiaparelli	92.37	28.87	+ 0.32	0.89	+0.069	3	Burnham
83.09	264.97	— 4.52	0.962	—0.071	4	Struve	92.65	31.65	— 0.38	0.835	+0.157	4	Hall
83.53	262.12	+ 1.46	0.74	+0.200	3	Burnham	94.19	37.19	+ 2.97	1.45	—0.272	2	Barnard
83.57	261.05	+ 2.90	0.837	+0.099	3	Hough	94.46	38.04	+ 3.40	0.952	+0.255	4	Hough
83.58	262.95	+ 1.02	0.663	+0.270	3	Hall	94.52	48.02	— 6.29	1.447	—0.234	2	Flint
1883.58	261.42	+ 2.55	0.865	+0.068	2	Frisby	1894.54	38.72	+ 3.11	1.168	+0.048	3	Stone

a, very difficult. *b*, *s* uncertain. *c*, uncertain.

In the discussion of his work on double stars W. Struve pointed out the need of confining observations to the brighter pairs, in order that the data may be sufficient for an accurate knowledge of the motions. Certainly the necessity of continuous and accurate observations is very great in this branch of astronomy. The sporadic observations are of little use. A catalogue of the double stars known to be physically connected would be useful, since it would tend to direct the attention of astronomers to objects that should be steadily observed. But such a catalogue should include stars like *μ¹ Herculis*, and other faint pairs of rapid motion which have been recently discovered.

1894 *July* 26.

ANNOUNCEMENT OF ESTABLISHMENT OF THE LOWELL OBSERVATORY.

[From a letter to the Editor.]

I beg to inform you officially that I have put up a temporary observatory, known as the Lowell Observatory, at Flagstaff, Arizona Territory, in longitude 111° 40′ W., latitude 35° 11′ N., chiefly for the study of the planet *Mars* during the present year. My astronomical address is at the observatory.

Percival Lowell, *Director Lowell Observatory.*

REQUEST FOR OBSERVATIONS OF COMET 1879 V.

I have taken up the investigation of the orbit of comet 1879 V, and would like to receive at once any unpublished observations.

Kurt Laves.

CORRIGENDUM.

No. 321, p. 69, col. 2, line —2, *for* minima *put* maxima.

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Request for Observations of Comet 1879 V.
Corrigendum.

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MICROMETRICAL OBSERVATIONS OF THE FIFTH SATELLITE OF *JUPITER* DURING THE OPPOSITION OF 1893, WITH MEASURES OF DIAMETERS OF *JUPITER*, 1892–4,

MADE WITH THE 36-INCH EQUATORIAL OF THE LICK OBSERVATORY,

By E. E. BARNARD.

Designation of the Satellite. So far no name has been given to the new satellite. This is principally because the mythological names long ago assigned to the other four are never used in practice, and promise eventually to be altogether dropped. It is far more convenient to speak of these moons as I, II, III and IV, than to write or say *Io*, *Europa*, *Ganymede* and *Callisto*.

The numerals, to me at least, stand as names, and do not necessarily have any bearing on the relative distances of the satellites. It would be dangerous and absurd to change the present notation to introduce the new satellite as I, and it would be equally absurd to call it 0, as some have suggested, for we can not tell what development the great telescopes of the future may bring about in the Jovian satellite-system.

I think, therefore, that this new moon should continue to be called the "Fifth Satellite," or Satellite V, as I have always called it. This will also be correct if we assume the other satellites were numbered in the order of discovery, which can be done without violating the facts.

There is certainly nothing to be gained by giving this object a special mythological name. However, if it is the general desire of astronomers that it should bear such a name, I will select one for it.

The other satellites of the solar system (except that of *Neptune*) are suitably named, and those names have come into regular use. Why not let the magnificent Jovian system differ from all the rest by a different order of nomenclature?

Brightness. No opportunity has yet offered for a direct comparison of the satellite and a star, so that its light is still undetermined with certainty. From numerous considerations, however, I am confident it cannot be brighter than 13^{M}, which should, for the present at least, be considered to represent its brightness.

Visibility at Different Oppositions. Telescopes capable of dealing with it should secure as many observations of this satellite as possible during the next two or three oppositions, as it is probable it will not be observable with even the 36-inch when the planet runs low south at the fainter apparitions.

The following table will show the relative brightness at different oppositions throughout a revolution of *Jupiter* about the sun. The light at the time of discovery, 1892 Sept. 9, is taken as unity.

Opposition	Brightness	Opposition	Brightness
1885	0.74	1892	1.08
1886	0.70	1893	1.01
1887	0.71	1894	0.90
1888	0.76	1895	–
1889	0.85	1896	0.80
1890	0.97	1897	0.72
1891	1.06		

When seen last at the opposition of 1892, 1893 Jan. 8, its light was 0.69, and at reobservation, 1893 Sept. 3, it was 0.75.

The Micrometer-Measures. Following are the measures that I have been able to obtain during the past opposition. As in the previous work, the planet has been obscured by a piece of smoked mica, thus preventing the eye from being blinded to the light of the satellite.

The direct measures were made from the nearest limb of the planet, and have been corrected for phase by MARTH's invaluable ephemeris. No correction has been applied for refraction. The observations have been made throughout with a magnifying power of 350.

The satellite has been fainter this opposition, but not more than could be accounted for by increase of distance and poor seeing.

The records, as in all the previous observations, are in Standard Pacific Time, which is 8 hours slow of Greenwich.

The accuracy in some of the measures has been more or less vitiated by the vibration of the telescope-tube from the wind blowing upon it through the observing slit, and not through any fault in the construction of the telescope itself.

And I would here once more emphatically call attention to the absolute necessity, in building domes for large telescopes, of a wind-break for the observing slit. It takes but a little breeze blowing upon the great length of tube to set it in vibration, and when in this condition it is exasperating in the extreme to attempt measures of objects 0″.5 or so apart—the greater the distance the more difficult and uncertain are the measures.

The great telescopes of Nice and Meudon are supplied with these wind-breaks; the one at Meudon being, I think, the most effective. This was designed and made by M. Gauthier. It consists of a canvas curtain, running up in the slit, and which is easily drawn to any desired height by a cord hanging within reach of the observer. Such a contrivance insures accuracy and expediency in micrometer-work with big telescopes. I should think it would also improve the definition, as it would prevent the air in the dome being set in commotion. It is never wanted above the glass, and that portion of the slit is open for a gentle equalization of the temperature.

1893 *September* 3.

Standard Pac. Time	Circle	Δ from W. limb	Δ from center
h m s	r	″	″
13 9 44	13.333	32.84	53.71
13 16 14	13.028	29.82	50.69
13 21 59	13.028	29.82	50.69
13 24 54	12.910	28.66	49.53
13 27 14	12.971	29.26	50.13
13 28 59	13.032	29.86	50.73
13 30 49	12.849	28.05	48.92
13 39 29	12.755	27.12	47.99

1893 *September* 15.

		Δ fr. E. limb	
16 14 50	8.253	18.36	40.46
16 16 5	8.139	19.49	41.59
16 18 46	8.010	20.76	42.86
16 20 40	8.012	20.74	42.84
16 22 20	7.938	21.48	43.58
16 23 50	7.944	21.42	43.52
16 25 17	7.796	22.88	44.98
16 27 10	7.873	22.12	44.22
16 29 33	7.748	23.36	45.46
16 30 50	7.630	24.53	46.63
16 33 27	7.599	24.83	46.93
16 37 0	7.482	25.99	48.09
16 39 15	7.390	26.90	49.00
16 41 20	7.443	26.38	48.48
16 42 52	7.339	27.41	49.51
16 44 33	7.304	27.76	49.86
16 46 20	7.300	27.80	49.90
16 47 27	7.245	28.34	50.44
16 49 5	7.235	28.44	50.54
16 50 15	7.285	27.94	50.04
16 53 20	7.178	29.00	51.10

1893 *September* 17.

Standard Pac. Time	Circle	Δ from E. limb	Δ from center
16 47 5	7.066	30.04	52.28
16 48 3	7.081	29.89	52.13
16 48 55	7.126	29.45	51.69
16 49 49	7.037	30.33	52.57
16 50 55	7.027	30.43	52.67
16 52 15	6.996	30.74	52.98
16 53 40	6.961	31.08	53.32
16 54 40	6.895	31.74	53.98
16 55 13	6.958	31.11	53.35
16 56 40	6.936	31.33	53.57
16 57 42	6.878	31.90	54.14
h m s	r	″	″
16 58 33	6.905	31.64	53.88
16 59 35	6.860	32.08	54.32
17 0 15	6.913	31.56	53.80
17 1 20	6.858	32.10	54.34
17 2 10	6.815	32.53	54.77
17 2 55	6.815	32.53	54.77
17 3 45	6.868	32.00	54.24
17 4 35	6.779	32.88	55.12
17 5 50	6.814	32.54	54.78
17 6 25	6.854	32.14	54.38
17 7 15	6.915	31.54	53.78
17 8 5	6.718	33.49	55.73
17 9 10	6.792	32.76	55.00
17 9 50	6.740	33.27	55.51
17 10 45	6.760	33.07	55.31
17 11 45	6.864	32.04	54.28
17 12 40	6.844	32.24	54.48

1893 *September* 24.

Standard Pac. Time	Circle	Δ from E. limb	Δ from center
15 9 17	8.881	12.35	35.06
15 10 44	8.723	13.91	36.62
15 12 35	8.674	14.40	37.11
15 16 34	8.446	16.66	39.37
15 18 5	8.428	16.83	39.54
15 19 37	8.391	17.20	39.91
15 21 0	8.289	18.21	40.92
15 22 25	8.272	18.38	41.09
15 23 35	8.218	18.91	41.62
15 25 30	8.123	19.85	42.56
15 35 37	7.795	23.10	45.81
15 37 0	7.820	22.85	45.56
15 38 10	7.805	23.00	45.71
15 40 20	7.725	23.79	46.51
15 41 23	7.720	23.84	46.55
15 42 18	7.616	24.87	47.58
15 59 6 (?)	7.255	28.45	51.16
16 0 35	7.204	28.95	51.66
16 11 17	7.029	30.69	53.40
16 13 15	6.989	31.08	53.79
16 16 20	6.887	32.09	54.80
16 42 30	6.735	33.60	56.31
16 44 20	6.845	32.51	55.22
16 46 0	6.690	34.04	56.75
17 4 30	6.787	33.08	55.79
h m s	r	″	″
17 6 0	6.815	32.81	55.52
17 7 22	6.707	33.87	56.58
17 18 55	6.870	32.26	54.97
17 20 10	6.950	31.47	54.18
17 22 30	7.015	30.82	53.53
17 24 0	7.054	30.44	53.15
17 26 35	7.066	30.32	53.03

		Δ fr. S. limb	β
15 28 25	7.712	23.92	+2.62
15 29 35	7.683	24.21	+2.91
15 30 35	7.732	23.73	+2.43

		Δ fr. N. limb	
15 31 30	12.068	19.21	+2.09
15 32 30	12.051	19.04	+2.26
15 33 20	12.045	18.98	+2.32

1893 *September* 25.

		fr. E. limb	fr. center
15 36 9	7.727	23.76	46.54
15 37 23	7.623	24.79	47.57
15 39 18	7.575	25.27	48.05
15 40 23	7.591	25.11	47.89
15 41 53	7.518	25.83	48.61
15 43 8	7.507	25.94	48.72
16 59 8	13.543	33.83	56.61
17 0 38	13.455	32.95	55.73
17 1 33	13.492	33.32	56.10
17 2 33	13.326	31.68	54.46
17 14 1	13.337	31.78	54.56
17 15 16	13.348	31.89	54.67
17 16 43	13.341	31.82	54.60
17 19 38	13.265	31.07	53.85
17 22 48	13.211	30.54	53.32

1893 *October* 1.

15 29 31	6.998	30.86	54.03
15 31 25	7.067	30.18	53.35
15 32 55	7.010	30.75	53.92
15 34 30	6.999	30.85	54.02
15 43 45	6.902	31.81	54.98
16 7 0	6.697	33.85	57.02
16 13 56	6.679	34.02	57.19
16 15 26	6.705	33.77	56.94
16 16 34	6.638	34.43	57.60

1893 *October* 1.—Cont.

Standard Pac. Time	Circle	Δ from E. limb	Δ from center
h m s	r	″	″
16 18 1	6.698	33.84	57.01
16 19 38	6.635	34.46	57.63
16 21 5	6.688	33.93	57.10
16 24 20	6.575	35.05	58.22
16 25 25	6.665	34.16	57.33
16 54 7	7.051	30.34	53.51
16 56 4	7.034	30.51	53.68
16 57 20	7.117	29.69	52.86
16 58 7	7.158	29.28	52.45
16 59 5	7.132	29.54	52.71
17 1 20	7.214	28.73	51.90
17 5 42	7.240	28.47	51.64
17 7 52	7.306	27.81	50.98
17 10 17	7.425	26.34	49.51
17 11 52	7.439	26.50	49.67
17 16 38	7.573	28.17	48.34
17 17 56	7.612	24.78	47.95
17 19 25	7.675	24.16	47.33
17 21 50	7.710	23.81	46.98
17 23 30	7.794	22.98	46.15
17 24 55	7.799	22.93	46.10

1893 *October* 2.

Standard Pac. Time	Circle	Δ from E. limb	Δ from center
14 51 16	7.812	22.93	46.17
14 52 58	7.885	22.21	45.45
14 54 59	7.764	23.41	46.65
14 56 53	7.663	24.41	47.65
14 58 23	7.670	24.34	47.58
14 59 44	7.511	25.91	49.15
15 1 36	7.582	25.21	48.45
15 2 46	7.518	25.84	49.04
15 4 36	7.485	26.17	49.41
15 7 41	7.457	26.45	49.69
15 9 48	7.322	27.79	51.03
15 11 51	7.314	27.86	51.10
15 56 24	6.728	33.67	56.91
15 58 11	6.605	34.88	58.12
16 9 31	6.622	34.72	57.96
16 12 16	6.609	34.85	58.09
16 13 21	6.599	34.95	58.19
16 15 1	6.666	34.28	57.52
16 29 6	6.752	33.43	56.67
16 30 29	6.809	32.87	56.11
16 31 26	6.707	33.87	57.11
16 40 38	6.849	32.47	55.71
16 42 23	6.913	31.83	55.07
16 45 43	6.969	31.24	54.48
16 47 33	7.065	30.33	53.57
16 49 36	7.035	30.63	53.87
16 51 31	7.133	29.66	52.90
16 53 16	7.173	29.26	52.50
16 58 54	7.312	27.88	51.12
17 0 1	7.281	28.16	51.40
17 1 16	7.331	27.70	50.94
17 14 16	7.733	23.72	46.96
17 16 41	7.765	23.41	46.65

1893 *October* 16.

Standard Pac. Time	Circle	Δ from E. limb	Δ from center
13 31 31	27.898	20.86	44.89

1893 *October* 16.—Cont.

Standard Pac. Time	Circle	Δ from E. limb	Δ from center
h m s	r	″	″
13 33 33	27.780	22.03	46.06
13 35 5	27.678	23.04	47.07
13 36 7	27.580	24.01	48.04
13 37 55	27.604	23.77	47.80
13 39 0	27.560	24.21	48.24
13 40 13	27.553	24.28	48.31
13 41 45	27.521	24.60	48.63
13 42 50	27.430	25.50	49.53
13 44 6	27.357	26.22	50.25
13 45 27	27.380	25.99	50.02
13 51 51	27.154	28.23	52.26
13 56 32	27.038	29.38	53.41
13 58 27	27.046	29.30	53.33
14 0 28	26.991	29.84	53.87
15 29 29	26.913	30.62	54.65
15 30 55	26.835	31.39	55.42
15 32 52	26.769	32.04	56.07
15 35 0	26.938	30.37	54.40
15 36 30	26.949	30.26	54.29
15 42 40	27.169	28.08	52.11

1893 *October* 29.

Standard Pac. Time	Circle	Δ from E. limb	Δ from center
12 9 57	28.084	19.04	43.62
12 11 23	28.074	19.14	43.72
12 16 20	27.969	20.18	44.76
12 17 36	27.805	21.81	46.39
12 19 22	27.867	21.19	45.77
12 20 20	27.850	21.36	45.94
12 22 0	27.709	22.76	47.34

1893 *November* 6.

Standard Pac. Time	Circle	Δ from E. limb	Δ from center
11 6 27	28.807	11.81	36.58
11 7 57	28.845	11.44	36.21
11 8 53	28.713	12.75	37.52
11 9 56	28.763	12.25	37.02
11 11 12	28.733	12.55	37.32
11 12 0	28.645	13.42	38.19
11 13 37	28.625	13.62	38.39
11 15 28	28.385	15.99	40.76
11 16 28	28.451	15.33	40.10
11 17 13	28.436	15.19	40.26
11 18 45	28.415	15.70	40.47
11 27 39	28.068	19.13	43.90
11 28 55	28.001	19.80	44.57
11 30 12	27.891	20.88	45.65
11 31 23	27.862	21.17	45.94
11 34 38	27.789	21.89	46.66
11 35 39	27.775	22.03	46.80
12 22 45	26.579	33.87	58.64
12 24 15	26.548	34.18	58.95
12 25 22	26.470	34.95	59.72
12 26 5	26.515	34.51	59.28
12 27 35	26.589	33.78	58.55
12 28 40	26.510	34.56	59.33
12 30 38	26.447	35.18	59.95
12 31 40	26.458	35.07	59.84
12 32 30	26.339	36.25	61.02
12 33 40	26.351	36.13	60.90
12 35 5	26.378	35.86	60.63

1893 *November* 6.—Cont.

Standard Pac. Time	Circle	Δ from E. limb	Δ from center
h m s	r	″	″
12 36 37	26.421	35.44	60.21
12 37 38	26.380	35.84	60.61
12 38 25	26.320	36.44	61.21
12 45 28	26.317	36.47	61.24
12 46 35	26.299	36.65	61.42
12 47 53	26.278	36.85	61.62
12 49 0	26.342	36.22	60.99
12 50 2	26.289	36.75	61.52
12 51 35	26.282	36.82	61.59
12 52 33	26.345	36.19	60.96
12 53 40	26.229	37.34	62.11
12 54 42	26.270	36.93	61.70
12 55 33	26.347	36.17	60.94
12 58 35	26.236	37.27	62.04
12 59 28	26.261	37.02	61.79
13 1 14	26.289	36.75	61.52
13 2 4	26.313	36.51	61.28
13 2 49	26.332	36.32	61.09
13 4 13	26.282	36.82	61.59
13 45 15	27.014	29.57	54.34
13 46 45	26.903	30.67	55.44
13 47 30	26.978	29.92	54.69
13 48 22	26.970	30.00	54.77
14 4 51	27.452	25.23	50.00
14 7 10	27.560	24.16	48.93
14 10 55	27.643	23.34	48.11
14 11 33	27.714	22.64	47.41
14 12 43	27.721	22.54	47.31
14 13 58	27.811	21.67	46.44
14 16 18	27.851	21.27	46.04
14 17 13	27.929	20.51	45.28
14 19 40	27.900	20.79	45.56

		Δ fr. S. limb	β
11 39 30	27.546	24.30	+1.07
11 40 37	27.526	24.50	+1.27
11 41 25	27.575	24.01	+0.78
11 42 7	27.623	23.54	+0.31

		Δ fr N. limb	
11 47 57	32.269	22.47	+0.76
11 43 39	32.252	22.30	+0.93
11 44 7	32.273	22.51	+0.72
11 45 0	32.241	22.22	+1.01

1893 *November* 12.

		fr.E.limb	fr.center
10 56 38	27.858	21.34	46.19
10 58 8	27.807	21.84	46.69
10 59 17	27.809	21.82	46.67
11 0 38	27.754	22.37	47.22
11 1 33	27.739	22.52	47.37
11 2 39	27.659	23.31	48.16
11 4 45	27.646	23.44	48.29
12 55 35	26.610	33.70	58.55
12 56 56	26.619	33.61	58.46
12 57 42	26.611	33.70	58.55
13 9 5	26.849	31.33	56.18
13 11 9	26.875	31.07	55.92
13 13 22	26.954	30.29	55.14

1893 *November* 12. — Cont.

Standard Pac. Time h	m	s	Circle r	Δ from E. limb ″	Δ from center ″
13	20	47	27.169	28.16	53.01
13	22	7	27.141	28.74	53.59
13	23	19	27.246	27.40	52.25
13	26	5	27.282	27.04	51.89
13	27	38	27.238	27.48	52.33
13	28	49	27.318	26.69	51.54
13	34	22	27.588	24.01	48.86
13	35	48	27.588	24.01	48.86
13	36	48	27.567	24.22	49.07
13	38	52	27.695	22.95	47.80
13	41	58	27.810	21.81	46.66
13	44	28	27.890	21.02	45.87
				Δ fr. S. limb	β
11	13	59	27.469	25.16	+1.85
11	15	5	27.453	25.35	+2.04
11	15	50	27.466	25.22	+1.91
11	16	33	27.519	24.70	+1.39
				Δ fr. N. limb	
11	17	52	32.213	21.78	+1.53
11	18	38	32.157	21.23	+2.08
11	19	22	32.208	21.73	+1.58
11	19	58	32.203	21.68	+1.63

1893 *November* 13.

h	m	s	Circle	Δ fr. E. limb.	
12	26	48	26.270	36.48	61.34
12	29	0	26.301	36.17	61.03
12	30	20	26.251	36.67	61.53
12	31	50	26.313	36.05	60.91
12	33	23	26.261	36.57	61.43
				Δ fr. S. limb	
12	36	50	27.647	22.84	−0 47
12	38	8	27.622	23.09	−0.22
12	39	0	27.664	22.68	−0.63
				Δ fr. N. limb	
12	40	25	32.460	24.81	−1.51
12	41	15	32.475	24.96	−1.65
12	42	15	32.475	24.96	−1.65

I am not able to explain the discrepancy in these latitude-measures. There is a difference of about 1″ in the latitudes as derived by measures from the south and the north limbs.

The distance-measures from the following limbs seem to be fairly in accord with what they should be, for elongation should have occurred at $12^h 16^m$ at a distance of 61″.72. It is evident, therefore, that the adopted value of the wire-coincidence determined immediately at the close of the measures could have nothing to do with it.

The latitude should have been about —0″.7, differing 0″.3 from the mean of the two sets of measures.

1893 *November* 19.

h	m	s	Circle	fr. E. limb	fr. center
10	5	8	19.060	15.19	40.05
10	6	41	18.974	16.04	40.90
10	7	36	18.951	16.27	41.13
10	8	23	18.920	16.58	41.44
10	9	3	18.829	17.48	42.34
10	10	6	18.910	16.68	41.54

1893 *November* 23. — Cont.

Standard Pac. Time h	m	s	Circle r	Δ from E. limb ″	Δ from center ″
10	11	8	18.798	17.79	42.65
10	12	0	18.841	17.36	42.22
10	12	43	18.755	18.21	43.07
10	13	36	18.710	18.66	43.52
11	40	31	16.902	36.56	61.42
11	41	43	16.883	36.75	61.61
11	42	31	16.884	36.74	61.60
11	43	26	16.862	36.95	61.81
11	44	31	16.860	36.97	61.83
11	47	21	16.922	36.36	61.22
11	48	49	16.843	37.14	62.00
12	33	1	17.470	30.93	55.79
12	34	21	17.572	29.92	54.78
12	35	51	17.528	30.36	55.22
12	38	16	17.621	29.44	54.30
12	39	43	17.697	28.69	53.55
12	58	31	18.193	23.77	48.63
12	59	57	18.217	23.54	48.40
13	1	11	18.276	22.95	47.81
13	2	16	18.325	22.47	47.33
13	4	0	18.337	22.35	47.21
13	5	21	18.404	21.68	46.54
13	7	51	18.498	20.75	45.61
13	9	11	18.555	20.19	45.05
13	10	16	18.676	18.99	43.85
13	11	49	18.682	18.93	43.79
				Δ fr. S. limb	β
12	50	23	18.369	22.03	−1.28
12	51	16	18.309	22.63	−0.68
12	52	13	18.365	22.07	−1.24
				Δ fr N. limb	
12	53	13	23.158	25.39	−2.08
12	54	10	23.097	24.78	−1.47
12	55	8	23.133	25.14	−1.83

1893 *December* 10.

h	m	s	Circle	fr. E. limb	fr. center
8	33	50	18.156	24.18	48.44
8	35	51	18.124	24.50	48.76
8	37	52	18.019	25.54	49.80
8	39	52	18.008	25.65	49.91
8	42	15	17.910	26.62	50.88
9	9	55	17.239	33.26	57.52
9	11	17	17.218	33.47	57.73
9	12	23	17.243	33.22	57.48
9	18	52	17.155	34.09	58.35
9	15	5	17.175	33.89	58.15
9	39	0	16.961	36.01	60.27
9	40	6	16.896	36.66	60.92
9	41	6	16.918	36.44	60.70
9	42	17	16.932	36.30	60.56
9	43	7	16.888	36.74	61.00
				Δ fr. S. limb	β
8	46	5	18.195	23.79	+0.96
8	47	30	18.168	24.06	+1.23
8	48	27	18.178	23.96	+1.13
8	49	25	18.170	24.04	+1.21

1893 *December* 10. — Cont.

Standard Pac. Time h	m	s	Circle r	Δ from N. limb ″	β ″
8	50	38	22.751	21.32	+1.51
8	52	17	22.811	21.91	+0.92
8	53	7	22.772	21.53	+1.30
8	54	13	22.786	21.67	+1.16

1893 *December* 18.

h	m	s	Circle	fr. E. limb	fr. center
10	30	39	18.579	20.05	43.84
10	32	2	18.613	19.72	43.51
10	33	19	18.637	19.48	43.27
10	32	59	18.710	18.76	42.55
10	37	53	18.801	17.86	41.65

1894 *January* 10.

h	m	s	Circle	fr. E. limb	fr. center
6	56	55	18.106	33.50	55.70
6	59	0	18.069	33.86	56.06
7	0	35	18.078	33.78	55.98
7	1	50	18.048	34.07	56 27
7	3	0	18.084	33.72	55.92
7	4	50	18.102	33.54	55.74
7	6	10	18.108	33.48	55.68
7	7	30	18.041	34.14	56.34
7	9	20	18.232	32.25	54.45
7	12	5	18.043	34.12	56.32
7	13	20	18.109	33.47	55.67
7	14	35	18.085	33.71	55.91
7	16	20	18.045	34.10	56.30
7	17	55	18.114	33.42	55.62
7	19	20	18.085	33.71	55.91
7	21	30	18.063	33.92	56.12
7	23	15	18.087	33.69	55.89
7	24	30	18.279	31.78	53.98
7	25	45	18.168	32.88	55.08
7	27	0	18.225	32.32	54.52
7	28	30	18.133	33.23	55.43
7	29	56	18.174	32.83	55.03
7	31	50	18.112	33.44	55.64
7	33	55	18.287	31.71	53.91
7	34	55	18.335	31.23	53.43
7	36	50	18.266	31.91	54.11
7	40	8	18.447	30.12	52.32
7	42	0	18.323	31.35	53.55
7	43	25	18.359	30.99	53.19
7	45	30	18.484	29.76	51.96
7	46	30	18.462	29.97	52.17
7	49	10	18.483	29.77	51.97
7	50	25	18.543	29.17	51.37
7	52	20	18.560	29.00	51.20
7	55	50	18.590	28.71	50.91
7	57	50	18.670	27.91	50.11

1894 *January* 28.

h	m	s	Circle	fr. E. limb	fr. center
6	27	26	18.854	26.24	46.89
6	28	16	18.969	25.10	45.75
6	28	56	18.882	25.96	46.61
6	29	56	18.959	25.20	45.85
6	30	56	18.936	25.43	46.08

1894 *January* 28.—Cont.

Standard Pac. Time	Circle	Δ from E. limb	Δ from center
h m s	r	″	″
6 31 56	18.982	24.97	45.62
6 32 41	18.989	24.90	45.55
6 33 26	18.991	24.88	45.53
6 34 16	19.080	24.00	44.65
6 35 6	19.091	23.89	44.54
6 36 16	19.034	24.46	45.11
6 38 6	19.129	24.52	45.17
6 39 26	19.161	23.20	43.85
6 41 56	19.225	22.57	43.22
6 42 56	19.289	21.93	42.58
6 44 3	19.243	22.38	43.03
6 46 3	19.353	24.30	41.95

Following is a list of the values of coincidence of the wires used in the reductions.

Date	Coincidence
	r
Sept. 3	10.016
15	10.107
17	10.100
24	10.128
25	10.127
Oct. 1	10.115
2	10.124
16	30.005
29	30.007
Nov. 6	30.000
12	30.013
13	29.954
19	20.594
Dec. 10	20.598
18	20.604
Jan. 10	21.489
28	21.504

In the observations it has always been customary to carefully place the wires parallel with the belts of *Jupiter*, and then, for the equatorial distances, to set the wires perpendicular to this by the position-circle, and clamp the micrometer in this position throughout the measures.

A record has been kept of these settings, from which the following table of position-angles of the belts, and consequently of the equator, has been obtained.

Of course if a special series of observations had been made to determine these quantities, more accordant results would have been obtained. The number of settings is indicated in brackets, from which the relative values can be inferred.

They are a continuation of those given in *A.J.*, 285–286.

POSITION-ANGLES OF *Jupiter's* BELTS.

	d	h	m	°	
1892					
Dec.	29	7	35	66.5	[5]
1893					
Jan.	5	8	10	65.1	[1]
Jan.	8	7	20	66.0	[2]
Aug.	27	14	0	77.5	[2]
Sept.	3	13	0	77 2	[1]
Sept.	15	15	20	77.9	[3]
Sept.	17	16	40	78.0	[1]
Sept.	24	14	30	78.5	[1]
Oct.	1	15	20	77.4	[1]
Oct.	29	12	0	77.3	[2]
Nov.	6	12	30	77.4	[5]
Nov.	12	14	30	76.7	[3]
Nov.	13	12	0	76.3	[1]
Nov.	19	11	0	76.1	[3]
Dec.	10	8	5	74.9	[4]
Dec.	18	10	20	75.4	[1]
1894					
Jan.	10	6	40	74.4	[2]
Jan.	28	6	20	75.5	[1]
Feb.	25	6	30	75.2	[3]
Feb.	26	6	30	75.9	[2]
Mar.	11	6	24	75.4	[1]

MEASURES OF THE DIAMETERS OF *Jupiter*.

During the observations of this satellite I have carried on a series of measures of the equatorial and polar diameters of *Jupiter*, to make my series of measures rest alone on my own work, and therefore more homogeneous.

These measures in the main are accordant, and being the only ones made with such a powerful telescope, should be valuable outside of their present purpose.

In comparing these measures with others made with different instruments, I have been surprised at the remarkable discrepancy between these (and other filar-micrometer measures) and measures made with heliometers. The filar-micrometer measures give a diameter about 1″ greater than that from the heliometer.

This is a peculiarity which I think is due to the condition of the images formed in the heliometer. From the fact that the images formed by that instrument come from two separate parts of an object glass, one would expect them to be defective, and not clear cut and perfect, as in the case of the image formed by a single perfect objective. In bringing these defective images in contact it seems to me that the points of tangency would be more or less uncertain on account of the poor images, and the true diameter therefore would not be obtained. It seems to me, also, that for measures of the diameters of the planets the heliometer is a defective instrument, and must lead to erroneous results.

If, in my measures of the diameters of *Jupiter*, the wires were set 1″ nearer together, the limbs of the planet would protrude beyond the wires. I therefore do not think such heliometer-measures should be given preference, or even equality with careful filar-micrometer measures of the planets. I can see the advantage of the heliometer-measures where the images of the stars are to be superposed — two ill-defined points can be accurately enough superposed, but two ill-defined limbs of a planet can not be brought to accurate tangency.

I may be wrong in my reference to the poorness of the image of a planet in the heliometer. I have but once seen through such an instrument; the object looked at was a star, and it certainly appeared inferior to what would have been seen with a good whole objective.

I do not think the great light-grasping power has anything to do with the larger image, as shown in the measures of the 36-inch, through irradiation, for most of the measures were made through smoked mica, which dulled the image greatly.

I have reduced the measures of 1892, previously printed, and insert them here for completeness:

FILAR-MICROMETER MEASURES OF THE DIAMETERS OF *Jupiter*.

1892 Gr. M.T.	Equatorial Diameter				Polar Diameter	
	Observ'd	Phase	Cor. Val.	Dist. 5.20	Observ'd	Dist. 5.20
d h	″	″	″	″	″	″
July 8 23.5	40.44	+0.43	42.87	38.81	38.19	36.26
15 23.7	41.37	+0.44	41.81	38.84	. .	. .
22 23.6	42.27	+0.44	42.71	38.80	39.87	36.22
29 23.0	43.00	+0.44	43.44	38.59	40.85	36.29
Aug. 5 23.5	44.08	+0.42	44.50	38.65	41.58	36.11
12 23.5	44.78	+0.39	45.17	38.38	42.83	36.39
Sept. 10 22.5	48.93	+0.16	49.09	38.59	. .	. .
11 21.5	49.11	+0.15	49.26	38.64	. .	. .
12 22.0	48.97	+0.14	49.11	38.45	46.01	36.02
13 20.5	. .	. .	. .	.	46.10	36.03
14 20.0	49.18	+0.13	49.31	38.46	46.03	35.90
16 20.0	49.98	+0.11	50.09	38.92	46.57	36.19
23 19.5	50.24	+0.06	50.30	38.68	47.36	36.42
26 1.0	50.26	+0.05	50.31	38.58	. .	. .
27 20.5	. .	. .	. .	. .	47.25	36.17
Oct. 1 21.0	50.26	+0.02	50.28	38.35	. .	. .
2 21.0	50.20	+0.02	50.22	38.28	. .	. .
7 20.0	50.51	0.00	50.54	38.12	46.93	35.69
9 19.5	50.80	0.00	50.80	38.62	. .	. .
Oct. 16 21.2	50.25	0.00	50.25	38.25	48.13	36.64
21 19.0	49.95	+0.02	49.97	38.16	46.90	35.81
23 18.0	49.81	+0.03	49.84	38.12	46.85	35.84
28 17.7	49.89	+0.05	49.94	38.65	46.66	35.90
Nov. 4 17.1	49.18	+0.10	49.28	38.33	45.87	35.68
6 17.0	49.15	+0.11	49.26	38.45	. .	. .
11 16.0	48.53	+0.15	48.68	38.40	45.93	36.23
13 16.0	48.29	+0.17	48.46	38.40	. .	. .
20 16.1	47.40	+0.23	47.63	38.41	44.72	36.06
1893 Sept. 3 22.4	42.03	+0.41	42.44	38.39	. .	. .
15 23.7	43.96	+0.38	44.34	38.62	. .	. .
24 22.7	45.45	+0.33	45.78	38.80	. .	. .
Oct. 2 23.8	46.28	+0.28	46.56	38.58	. .	. .
Nov. 6 18.8	49.70	+0.03	49.73	38.65	46.49	36.17
19 17.5	50.00	0.00	50.00	38.73	46.87	36.30
Dec. 10 17.0	. .	. .	. .	. .	45.56	36.03
1894 Feb. 25 14.8	38.06	+0.35	38.41	38.24	36.18	36.02
26 14.7	38.22	+0.35	38.57	38.52	36.40	36.35

The mean of these give (at distance 5.20) for the

Equatorial diameter,	38″.522 ± 0″.024
Polar diameter.	36.112 ± 0.032

Prob. error of a single night ; equatorial diameter, ±0″.14
" " " " polar diameter. ±0.16

These diameter-measures have been uniformly made with 520 diameters.

These respectively correspond to the following values in miles:

Equatorial diameter = 90190 ± 56 miles
Polar diameter = 84570 ± 75 miles

I have made no correction to the polar diameter for inclination of the axis towards us. This correction, however, must be very small, and perhaps insensible in the main.

From these measures we have for the polar compression of *Jupiter*,

$$\frac{E-P}{E} = \frac{1}{15.98}$$

where E and P are the equatorial and polar diameters.

In comparison with the results obtained with the 36-inch, the following are some of the measures made elsewhere:

HELIOMETER-MEASURES.

	Equatorial	Polar	Compression
Bessel,	37″.60	35″.21	$\frac{1}{15.73}$
Winnecke,	37.43	35.11	$\frac{1}{16.10}$
Schur,	37.42	35.03	$\frac{1}{15.65}$

For these values I am indebted to the kindness of Professor W. SCHUR, whose observations were made in 1892, during the same period covered by the major part of my own observations.

It will be seen that these results are singularly accordant, but that they differ from mine by an entire second.

FILAR-MICROMETER MEASURES.

	Equatorial	Polar	Compression
Struve,	38″.33	35″.54	$\frac{1}{13.74}$
Secchi,	38.35	35.96	$\frac{1}{16.05}$
Hough,	38.96	36.66	$\frac{1}{16.94}$

DOUBLE-IMAGE MICROMETER.

	Equatorial	Polar	Compression
Kaiser,	37″.55	35″.15	$\frac{1}{15.65}$

By transits, VOGEL got for the equatorial diameter, 38″.37.

In looking over the great number of determinations of the dimensions of *Jupiter* with different observers and different instruments (only a few of which I have given), it would appear that the true size of this planet is a remarkably uncertain quantity. A new determination of its diameters with the most powerful telescope in existence should therefore be a welcome addition to the literature of the subject. It is to be regretted that the 36-inch has no double-image micrometer for such work.

I have reduced all the distance-measures of the opposition of 1893 with uniform values of the equatorial and polar diameters.

For this work I have adopted the following from my own observations:

Equatorial diameter,	38″.509 (at Δ 5.20)
Polar diameter.	36.112 (at Δ 5.20)

This value of the equatorial diameter differs from that finally derived from all the observations by 0″.013. As this quantity is very small. I have not made any correction for it.

From these values I have computed the following table of apparent diameters, which have been used in the reductions.

APPARENT DIAMETERS OF *Jupiter* USED IN THE REDUCTIONS OF 1893–4.

1893	Equatorial	Polar	1893	Equatorial	Polar
	″	″		″	″
Sept. 3	42.57	. .	Nov. 6	49.55	46.46
15	44.21	. .	12	49.71	46.61
17	44.49	. .	13	49.72	46.63
24	45.43	42.60	19	49.72	46.62
25	45.57	. .	Dec. 10	48.68	45.65
Oct. 1	46.35	. .	18	47.86	. .
2	46.48	. .	1894		
16	48.08	. .	Jan. 10	45.02	. .
29	49.16	. .	28	43.36	. .

The following phase-corrections have been applied to the equatorial semi-diameters before using:

	″		″
Sept. 3	−0.41	Jan. 10	−0.31
Dec. 10	−0.08	28	−0.53
18	−0.14		

Elongation-Distances. With the uniform value for the equatorial diameter of *Jupiter* I have corrected the previously determined values of elongations observed in 1892. They are also corrected for phase of the planet, and are here given.

ELONGATION-DISTANCES OF THE SATELLITE IN 1892.

1892	E. Elongation		W. Elongation	
	App.	Δ 5.20	App.	Δ 5.20
	″	″	″	″
Sept. 10	61.07	48.04	. .	. .
11	61.19	48.00	. .	. .
12	61.66	48.27	. .	. .
14	61.69	48.12	. .	. .
23	62.10	47.75	. .	. .
27	63.20	48.37	. .	. .
Oct. 7	63.49	48.29	. .	. .
9	63.31	48.13	62.17	47.27
17	. .	. .	62.16	47.34
23	63.11	48.30	62.22	47.59
28	62.66	48.20	62.21	47.86
Nov. 4	61.79	48.06	61.91	48.17
6	61.66	48.13	. .	. .
11	60.80	47.95	60.60	47.80
13	60.39	47.85	. .	. .
18	. .	. .	59.78	47.95
		48″.104 ±0″.061		47″.712 ±0″.176

The first of these corresponds to a distance of 112 650 miles.

I have carefully plotted the observations of 1893, where they cover the time of elongation, and from these plottings have derived the elongation-distances that follow.

EAST ELONGATIONS OF THE SATELLITE DERIVED GRAPHICALLY FROM THE MEASURES OF 1893–4.

	Observed	At Δ 5.20
	″	″
1893 Sept. 24	56.10	47.56
Oct. 1	57.45	47.73
2	57.60	47.72
Nov. 6	61.40	47.72
19	61.66	47.76
Dec. 10	60.84	48.12
1894 Jan. 10	55.98	47.88
		47.785 ± 0″.044

This would correspond to a distance of 111 910 miles.

The probable error doubtless does not represent the true value of the observations, as the elongation-distance is a varying quantity through the eccentricity and revolution of the orbit.

No observations could be obtained at west elongation during 1893.

A comparison of these results with those of 1892 shows conclusively. I think. that the orbit is nearly eccentric. to which I have previously called attention.

Indeed. M. TISSERAND finds that the major axis of the orbit of this satellite must make a complete revolution in about five months.

Elongation-Times. The following east elongation-times have been computed from measures on each side of elongation:

			Corr. to MARTH
		h m	m
1893 Oct.	1	16 11.8[illegible]	+ 9
	2	16 5.61	+ 9
Nov.	6	12 54.54	+10
	12	12 20.88	+10
	19	11 42.98	+11

These are in Standard Pacific Time, which is eight hours slow of Greenwich. The last column contains the correction to MARTH's ephemeris. *Mon. Not.*, LIII. 490.

I have made a corrected determination of the elongation-time of 1892 Sept. 10. which gives

East elongation, 1892 Sept. $10^d\ 12^h\ 48^m.2$ St. Pac. Time

This differs $0^m.7$ from the previously printed value of this elongation. and is to be preferred.

The following corrections have been applied to these times before they have been used for getting the periodic time.

Observed Standard Pacific Time 1892–3	Reduction to ⊙ at observation time	Reduction to ⊙ of 1892 Sept. 10	Reduction for Aberration to ⊙ of 1892 Sept. 10	St. P. Time red. to the ⊙ and dis. of 1892 Sept. 10
1892 d h m	h m	h m	h m	h m
Sept. 10 12 48.20	−0 13.25	. . . .	. . . .	12 34.95
1893 Oct. 1 16 11.84	−0 17.99	−1 9.86	−0 1.93	14 42.06
2 16 5.61	−0 17.72	−1 10.04	−0 1.83	14 36.02
Nov. 6 12 54.54	−0 4.94	−1 16.29	+0 0.35	11 33.66
12 12 20.88	−0 2.30	−1 17.36	+0 0.49	11 1.71
19 11 42.98	+0 0.83	−1 18.61	+0 0.49	10 25.69

From the corrected times in the last column, the following values of the periodic time directly result, the observation of 1892 Sept. 10 being taken as a base.

Elongation		Period	No. Notations
		h m s	
1893 Oct.	1	11 57 22.615	775
	2	11 57 22.554	777
Nov.	6	11 57 22.650	847
	12	11 57 22.607	859
	19	11 57 22.662	873

The mean of these gives for the sidereal period of satellite,

$$P = 11^h\ 57^m\ 22^s.618 \pm 0^s.013$$

The probable error of a single determination being $\pm 0^s.029$.

Determination of the Velocity of Light by Eclipses of the Fifth Satellite. Several astronomers have suggested, from the rapidity of motion and the smallness of the satellite, that we have here the means of an accurate redetermination of the velocity of light through space, by means of its eclipses.

It is altogether probable that this suggestion can not be put into practical use, since the eclipses, under the most favorable conditions, will always occur within 6″ or 8″ of the limb of *Jupiter.*

The satellite is usually lost in the glow and secondary spectrum at a distance greater than this, under the best conditions of visibility. Hence, what promises to be such an important factor in the determination of the velocity of light, it would seem, must be abandoned, at least so far as our present telescopes are concerned.

Mt. Hamilton, 1894 *July* 13.

NEW ASTRONOMICAL WORK.

Photometrische Durchmusterung des Nördlichen Himmels, enthaltend alle Sterne der B.D. bis Grosse 7.5. Theil I, zone 0° bis +20° declination. By G. Müller and P. Kempf. *Publicationen des Astrophysikalischen Observatoriums zu Potsdam, Nr.* 31, *Neunter Band.* Potsdam, 1894.

The appearance of this first of the four parts which this work is to include, constitutes an epoch in photometric astronomy. The undertaking may be properly called a great one, not merely from its extent, but from its high scientific character, which is assured as well by the reputation of its authors and of the institution from which it emanates, as by an intimate scrutiny of the contents of the portion now before us. This contains the zone 0° to +20°, with the details as to the construction and plan of the whole work, and the determination of the system of fundamental stars for the whole northern sky, which is to give to the completed undertaking its unity of character. The zone +20 to +40° will soon follow, and the zones +40 to +60°, and +60 to +90°, at as short intervals as possible thereafter.

In the introduction, after some general remarks, the errors of different photometric apparatus, and the relative advantages and disadvantages, theoretical and practical, of those hitherto most used, are considered. The preference is given to Zöllner's. Two photometers of this form were used in the work. The first was used with a refractor of 13.5 cm. aperture, especially for stars from 6^M to 8^M. The second was used with objectives of 67 mm. and 36.5 mm. aperture. The high degree of accuracy which experience showed to be attainable, led to a modification of the original plan, which contemplated four observations for each star, by limiting the number to two, one by each observer, except for those stars used in comparing the two instruments, and those in which the discordance exceeded certain moderate limits.

The first section treats of the selection and observation of the list of 144 fundamental stars, the determination of their definitive magnitudes, and the discussion of the results. These were chosen, avoiding double and strikingly colored stars, in three belts, at +10°, +30 and +60 declination; following each other in each belt at about 30^m of R.A., and alternately of about the magnitudes 5.0 and 6.7. Each star was compared with its two neighbors in the same belt, and also with one brighter and one fainter in each of the other belts; and so nearly in the same zenith-distance that the influence of atmospheric absorption was eliminated. Eight comparisons were made for each combination, half by each observer. The probable error of each mean value is $\pm 0^M.027$. There is an insignificant constant personal difference of $M-K = +0^M.03$. By successive approximate solution of all the equations, the final value of the magnitude of each star is found, so that the sum of the resulting magnitudes is accurately the sum of the DM. magnitudes for the 144 stars. It is believed that the magnitudes of these fundamental stars are fixed certainly within $0^M.05$.

The second section contains the details of the zone-observations. Each zone contains, in general, 12 zone-stars, all within narrow limits of brightness and declination; and 2 fundamental stars observed in pairs at the beginning, middle and end of the zone. Great care was used in identification, and it is believed that not a single false star was observed in the whole work: which was done in a deliberate manner, allowing on an average two minutes to a star. The authors remark that a greater speed could have been easily attained, but would have been prejudicial both to accuracy, and certainty of identification; and they attribute the extraordinarily large number of "discordant observations" and mis-identifications in the Harvard College work to the undue haste with which that work was conducted.

The catalogue of 3522 stars follows in the third section, with remarks on the results, and comparison with other catalogues. The probable error of an observation is found to be; for Potsdam $\pm 0^M.057$; for the "Harvard Photometry" $\pm 0^M.15$; for the Harvard "Revision of the DM." $\pm 0^M.20$. The volume concludes with some comments founded on an examination of the numerous errors and large discordances in these works.

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Micrometrical Observations of the Fifth Satellite of Jupiter During the Opposition of 1893, with Measures of Diameters of Jupiter, 1892–4, by Prof. E. E. Barnard.
New Astronomical Work.

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NOTE ON PROF. NEWCOMB'S DEVELOPMENT OF THE PERTURBATIVE FUNCTION,

BY A. CHESSIN.

In the development of the perturbative function given in the *Astr. Papers*, Part I, Vol. III, by Prof. NEWCOMB, certain operators $\Pi^{m,n}_{m',n'}$ have to be computed. The terms in the development of the perturbative function have the general form,

$$\text{(class 0)} \qquad \varepsilon^{n}\,\varepsilon'^{n'}\,\underset{(i)}{\mathrm{P}}{}^{n,n'}_{m,m'}\cos(\mathrm{V}_i+m'\eta'+m\eta)$$

$$\text{(class 1)} \qquad \sigma^2\,\varepsilon^{n}\,\varepsilon'^{n'}\,\underset{(i)}{\mathrm{Q}}{}^{n,n'}_{m,m'}\cos(\mathrm{V}_i'+m'\eta'+m\eta)$$

$$\text{(class 2)} \qquad \sigma^4\,\varepsilon^{n}\,\varepsilon'^{n'}\,\underset{(i)}{\mathrm{R}}{}^{n,n'}_{m,m'}\cos(\mathrm{V}_i''+m'\eta'+m\eta)$$

and so on, where

$$\underset{(i)}{\mathrm{P}}{}^{n,n'}_{m,m'} = \Pi^{n,n'}_{m,m'}\,\mathrm{A}_i$$

$$\underset{(i)}{\mathrm{Q}}{}^{n,n'}_{m,m'} = \Pi'^{n,n'}_{m,m'}\,\mathrm{B}_i$$

$$\underset{(i)}{\mathrm{R}}{}^{n,n'}_{m,m'} = \Pi''^{n,n'}_{m,m'}\,\mathrm{C}_i$$

and so on. For the meaning of all the symbols see Prof. NEWCOMB's paper.

A considerable reduction of work is obtained by the following modification, which makes the computation of the operators $\Pi^{m,n}_{m',n'}$ no more necessary. First of all, I remark, that *all the symbols* $\Pi^{m,n}_{m',n'}$, *in which the indices* m *and* m', n *and* n' *differ, can be expressed linearly in function of operators* $\Pi^{m,n}_{m,n}$, *in which the upper and lower indices are the same.* This is easily found by inspection of the formulas (31) in Prof. NEWCOMB's paper. Hence all is reduced to the computation of symbols of the form, $\Pi^{m,n}_{m,n}$.

I will here consider only the terms of the class 0.

We easily find from the formulas (31), p. 24, in Prof. NEWCOMB's paper, that

$$(1) \qquad \underset{(i)}{\Pi}{}^{m}_{m} = \frac{(-1)^m}{m\,!}(i+\mathrm{D})(i+\mathrm{D}-1)\,\ldots\,(i+\mathrm{D}-m+1)$$

$$(2) \qquad \underset{(i)}{\Pi}{}^{0,n}_{0,n} = \frac{1}{n\,!}(i+\mathrm{D}+1)(i+\mathrm{D}+2)\,\ldots\,(i+\mathrm{D}+n)$$

$$(3) \qquad \underset{(i)}{\Pi}{}^{m,n}_{m,n} = \underset{(i)}{\Pi}{}^{m}_{m}\cdot\underset{(i)}{\Pi}{}^{0,n}_{0,n} = \frac{(-1)^m}{m\,!\,n\,!}(i+\mathrm{D}+n)(i+\mathrm{D}+n-1)\ldots(i+\mathrm{D}-m+1)$$

Substituting $(i+m)$ for i in (3), we shall have

$$\underset{(i+m)}{\Pi}{}^{m,n}_{m,n} = \frac{(-1)^m(m+n)\,!}{m\,!\;n\,!}\,\pi_i^{(m+n)} \tag{4}$$

where

$$\pi_i^{(m+n)} = \frac{(i+\mathrm{D}+m+n)(i+\mathrm{D}+m+n-1)\ldots(i+\mathrm{D}+1)}{(m+n)\,!} \tag{5}$$

We see that the symbol $\pi_i^{(m+n)}$ depends *on the sum of* m *and* n, but not on their relative values.

It follows from (5), that

$$\pi_{i+1}^{(m+n)} = \pi_i^{(m+n)} + \pi_{i+1}^{(m+n-1)} \tag{6}$$

This formula is important.

Substituting in (6) $i+1, i+2, \ldots\ldots i+j-1$, for i we obtain

$$\pi_{i+2}^{(m+n)} = \pi_{i+1}^{(m+n)} + \pi_{i+2}^{(m+n-1)}$$

$$\pi_{i+3}^{(m+n)} = \pi_{i+2}^{(m+n)} + \pi_{i+3}^{(m+n-1)}$$

$$\ldots\ldots\ldots\ldots$$

$$\pi_{i+j}^{(m+n)} = \pi_{i+j-1}^{(m+n)} + \pi_{i+j}^{(m+n-1)}$$

Adding all these formulas and formula (6), we readily find

$$\pi_{i+j}^{(m+n)} = \pi_i^{(m+n)} + \sum_{e=1}^{e=j}\pi_{i+e}^{(m+n-1)} \tag{7}$$

If we put $i = 0$ in (7), the formula becomes

$$\pi_i^{(m+n)} = \pi_0^{(m+n)} + \sum_{e=1}^{e=i}\pi_e^{(m+n-1)} \tag{7$'$}$$

Before I proceed I will establish a formula of constant use. Suppose given a relation,

$$a_i^{(p)} = a_0^{(p)} + c_p\sum_{e=1}^{e=i}a_e^{(p-1)} \tag{8}$$

It is desired to express $a_i^{(p)}$ in function of

$$a_0^{(p)},\; a_0^{(p-1)},\; a_0^{(p-2)},\; \ldots\ldots$$

I say, that the desired form is

$$a_i^{(p)} = a_0^{(p)} + ic_p\, a_0^{(p-1)} + \frac{i(i+1)}{1\,.\,2}\, c_p\, c_{p-1}\, a_0^{(p-2)}$$

$$+ \frac{i(i+1)(i+2)}{1\,.\,2\,.\,3}\, c_p\, c_{p-1}\, c_{p-2}\, a_0^{(p-3)}$$

$$(9) \quad + \ldots + \frac{i(i+1)\ldots.(i+e-1)}{1\,.\,2\ldots.e}\, c_p\, c_{p-1} \ldots c_{p-e+1}\, a_0^{(p-e)} + \ldots$$

$$\ldots + \frac{i(i+1)\ldots.(i+p-1)}{1\,.\,2\ldots.p}\, c_p\, c_{p-1} \ldots c_1$$

if we agree that $a_e^{(0)} = 1$ and $a_e^{(-k)} = 0$, whatever be k.

The demonstration can be easily done by the usual method of supposing the formula correct for $p = p_1$ and proving its correctness for $p = p_1 + 1$. In the special case, when $c_p = 1$, formula (9) becomes (9)′

$$a_i^p = a_0^p + ia_0^{p-1} + \frac{i(i+1)}{1\,.\,2}\, a_0^{p-2} + \ldots. + \frac{i(+1)\ldots(i+p-1)}{1\,.\,2\ldots.p}$$

We now apply formula (9)′ to the case when $a_i^p = \pi_i^{(m+n)}$, as the symbols $\pi_i^{(m+n)}$ satisfy the relation (8), where $c_p = 1$. Hence, we must have

$$(10) \qquad \pi_i^{(m+n)} = \sum_{e=0}^{e=m+n} \frac{i(i+1)(i+2)\ldots(i+e-1)}{e\,!}\, \pi_0^{(m+n-e)}$$

or, if we agree in the notation,

$$\alpha_e^{(i)} = \frac{i(i+1)(i+2)\ldots.(i+e-1)}{e\,!}$$

$$\alpha_0 = 1$$

$$(10)' \qquad \pi_i^{(m+n)} = \sum_{e=0}^{e=m+n} \alpha_e^{(i)}\, \pi_0^{(m+n-e)}$$

It is obvious, that we would also have

$$(10)'' \qquad \pi_{i+j}^{(m+n)} = \sum_{e=0}^{e=m+n} \alpha_e^{(i)}\, \pi_j^{(m+n-e)}$$

if we applied formula (9)′ to the symbols $\pi_{i+j}^{(m+n)}$ instead of $\pi_i^{(m+n)}$.

In the above reasoning i was necessarily supposed positive. We shall establish now formulas for negative values of i. Formula (6) may be written thus:

$$(11) \qquad \pi_{(i-1)}^{m+n} = \pi_i^{(m+n)} - \pi_i^{(m+n-1)}$$

Substituting $i-1,\ i-2 \ldots\ldots,\ i-j+1$, for i in this formula, then adding them all, we readily obtain

$$(12) \qquad \pi_{i-j}^{(m+n)} = \pi_i^{(m+n)} - \sum_{e=0}^{e=j-1} \pi_{i-e}^{(m+n-1)}$$

If we put $i = 0$, (12) becomes

$$(13) \qquad \pi_{-i}^{(m+n)} = \pi_0^{(m+n)} - \sum_{e=0}^{e=i-1} \pi_{-e}^{(m+n-1)}$$

This formula does not belong to the type (8), but is included in the following one:

$$(14) \qquad \mathrm{C}_i^{(p)} = \mathrm{C}_0^{(p)} + \mathrm{C}_p \sum_{e=0}^{e=i-1} \mathrm{C}_e^{(p-1)}$$

I say, that in this case we have (15)

$$\mathrm{C}_i^{(p)} = \mathrm{C}_0^{(p)} + ic_p\, \mathrm{C}_0^{(p-1)} + \frac{i(i-1)}{1\,.\,2}\, c_p\, c_{p-1}\, \mathrm{C}_0^{(p-2)} + \ldots.$$

$$\ldots. + \frac{i(i-1)\ldots.(i-e+1)}{1\,.\,2\ldots.e}\, c_p\, c_{p-1} \ldots c_{p-e+1}\, \mathrm{C}_0^{(p-e)} + \ldots$$

$$\ldots. + \frac{i(i-1)\ldots.(i-p+1)}{1\,.\,2\ldots.p}\, c_p\, c_{p-1} \ldots. c_1$$

if we agree, that $\mathrm{C}_e^{(0)} = 1$ and $\mathrm{C}_e^{(-k)} = 0$, whatever be k. This formula can be proved in the same way as formula (9).

To apply (15) to our case, we must make

$$c_p = c_{p-1} = \ldots. = -1.$$

We then obtain

$$\pi_{-i}^{(m+n)} = \sum_{e=0}^{e=m+n} (-1)^e\, \beta_e^{(i)}\, \pi_0^{(m+n-e)} \tag{16}$$

where

$$\beta_e^{(i)} = \frac{i(i-1)\ldots.(i-e+1)}{e\,!} \tag{17}$$

and in like manner

$$\pi_{-i+j}^{(m+n)} = \sum_{e=0}^{e=m+n} (-1)^e\, \beta_e^{(i)}\, \pi_j^{(m+n-e)} \tag{16$'$}$$

It is to be understood, that $\beta_e^{(i)}$ is always positive, and that in the development (15) we must stop as soon as we arrive at a coefficient zero.

If, now, we write $(i-m)$ for i in (4), we shall have

$$\Pi_{\substack{m,\,n\\(i)}}^{m,\,n} = \frac{(-1)^m\,(m+n)\,!}{m\,!\ n\,!}\, \pi_\lambda^{(m+n)} \tag{18}$$

$$\lambda = i - m \tag{19}$$

$$\pi_\lambda^{(m+n)} = \sum_{e=0}^{e=m+n} \alpha_e^{(\lambda)}\, \pi_0^{(m+n-e)} \qquad \text{if } \lambda > 0 \tag{20}$$

$$\pi_\lambda^{(m+n)} = \sum_{e=0}^{e=m+n} (-1)^e\, \beta_e^{(-\lambda)}\, \pi_0^{(m+n-e)} \qquad \text{if } \lambda < 0 \tag{21}$$

$$\pi_\lambda^{(m+n)} = \pi_0^{(m+n)} \quad \text{for} \quad \lambda = 0 \tag{22}$$

$$\left.\begin{aligned} \pi_0^{(p)} &= \frac{(\mathrm{D}+1)(\mathrm{D}+2)\ldots.(\mathrm{D}+p-1)(\mathrm{D}+p)}{1\,.\,2\,.\,3\ldots.p} \\ \pi_0^{(0)} &= 1 \end{aligned}\right\} \tag{23}$$

Let us now apply the above operators to A_i, and let us put

$$p_i^{(\mu)} = \pi_0^{(\mu)}\, \mathrm{A}_i \tag{24}$$

$$\mathrm{P}_{i,\,\lambda}^{(\mu)} = \pi_\lambda^{(\mu)}\, \mathrm{A}_i \tag{25}$$

We find from (20) and (21), that

$$\mathrm{P}_{i,\,\lambda}^{(m+n)} = \sum_{e=0}^{e=m+n} \alpha_e^{(\lambda)}\, p_i^{(m+n-e)} \qquad \text{if } \lambda > 0 \tag{26}$$

$$P_{i,\,\lambda}^{(m+n)} = \sum_{e=0}^{e=m+n} (-1)^e\, \beta_e^{(-\lambda)}\, p_i^{(m-n-e)} \qquad \text{if } \lambda < 0 \tag{27}$$

and from (18), that

$$\underset{(i)}{\mathrm{P}^{m,n}_{m,n}} = (-1)^m \frac{(m+n)!}{m!\,n!}\,\mathrm{P}^{(m+n)}_{i,\lambda} \tag{28}$$

This is the modification of Prof. Newcomb's method of computing the coefficients $\underset{(i)}{\mathrm{P}^{m,n}_{m,n}}$ which I intended to show. The advantages are the following ones:

1. Formula (28) requires the computation of only one coefficient $\mathrm{P}^{(m+n)}_{i,\lambda}$ to obtain all the coefficients $\underset{(i)}{\mathrm{P}^{m,n}_{m,n}}$ for which $m+n = \text{const.}$ and $\lambda = i - m = \text{const.}$ We thus obtain at once all the coefficients:

$$\ldots\ldots,\ \underset{(i-2)}{\mathrm{P}^{m-2,\,n+2}_{m-2,\,n+2}},\ \underset{(i-1)}{\mathrm{P}^{m-1,\,n+1}_{m-1,\,n+1}},\ \underset{(i)}{\mathrm{P}^{m,\,n}_{m,\,n}},\ \underset{(i+1)}{\mathrm{P}^{m+1,\,n-1}_{m+1,\,n-1}},\ \underset{(i+2)}{\mathrm{P}^{m+2,\,n-2}_{m+2,\,n-2}},\ \ldots\ldots$$

2. After we got one set of these coefficients for the value $\lambda = \lambda_1$, we get the one for $\lambda = \lambda_1 + 1$ by a simple addition. In fact, it follows from (6), that

$$\pi^{(m+n)}_{\lambda+1} = \pi^{(m+n)}_{\lambda} + \pi^{(m+n-1)}_{\lambda+1} \tag{29}$$

and on account of (25), that

$$\mathrm{P}^{(m+n)}_{i,\lambda+1} = \mathrm{P}^{(m+n)}_{i,\lambda} + \mathrm{P}^{(m+n-1)}_{i,\lambda+1} \tag{30}$$

If, therefore, we have computed all the coefficients of the order $(m+n-1)$, and also have computed those of the order $(m+n)$ for the value λ, we obtain $\mathrm{P}^{(m+n)}_{i,\lambda+1}$ by a simple addition, and from the value of $\mathrm{P}^{(m+n)}_{i,\lambda+1}$ again the whole set of coefficients

$$\ldots\ldots\ \underset{(i-1)}{\mathrm{P}^{m-1,\,n+1}_{m-1,\,n+1}},\ \underset{(i)}{\mathrm{P}^{m,\,n}_{m,\,n}},\ \underset{(i+1)}{\mathrm{P}^{m+1,\,n-1}_{m+1,\,n-1}},\ \ldots\ldots$$

for $i - m = \lambda + 1$; and so on.

3. The whole computation is reduced to that of the coefficients $p^{(\mu)}_i$. The number of these coefficients is very limited, and their computation requires but little time, compared to the computation of the $\underset{(i)}{\mathrm{P}^{m,n}_{m,n}}$ by means of the direct operators $\underset{(i)}{\Pi^{m,n}_{m,n}}$.

4. Every computation, if not carried far enough, can be easily extended, without much labor; because all we need to do is to compute a set of coefficients $p^{(\mu)}_i$ for a new value of μ, namely, one coefficient for every value of i. It is well to notice, that $p^{(\mu)}_{(-i)} = p^{\mu}_{(i)}$.

To conclude, I will show how to compute the $\mathrm{D}^k \underset{(i)}{\mathrm{P}^{m,n}_{m,n}}$. We have from (5)

$$(i+\mathrm{D})\,\pi^{(m+n)}_i = \frac{(i+\mathrm{D})(i+\mathrm{D}+1)\ldots\ldots(i+\mathrm{D}+m+n)}{(m+n)!}$$

$$= (m+n+1)\,\pi^{(m+n+1)}_{i-1}$$

or, if we put again

$$\lambda = i - m$$

$$(\lambda+\mathrm{D})\,\pi^{(m+n)}_{\lambda} = (m+n+1)\,\pi^{(m+n+1)}_{\lambda-1} \tag{31}$$

Applying the operation on A_i, we find

$$\mathrm{DP}^{(m+n)}_{i,\lambda} = -\lambda\,\mathrm{P}^{(m+n)}_{i,\lambda} + (m+n+1)\,\mathrm{P}^{(m+n+1)}_{i,\lambda-1} \tag{32}$$

Multiplying all by $(-1)^m \dfrac{(m+n)!}{m!\,n!}$, we readily obtain

$$\mathrm{D}\underset{(i)}{\mathrm{P}^{m,n}_{m,n}} = -\lambda\,\underset{(i)}{\mathrm{P}^{m,n}_{m,n}} - (m+1)\,\underset{(i)}{\mathrm{P}^{m+1,n}_{m+1,n}} \tag{33}$$

The same operation can be repeated as many times as required, so that it is obvious that $\mathrm{D}^k\underset{(i)}{\mathrm{P}^{m,n}_{m,n}}$ can be linearly expressed in the coefficients $\underset{(i)}{\mathrm{P}^{m,n}_{m,n}}$.

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NOTES ON VARIABLE STARS,—No. 5.

By HENRY M. PARKHURST.

There has been a small error in the use of the eastern deflector in part of my observations, arising from deflection of the illumination. I have hitherto supposed this shading to be caused by imperfect construction; but the attempt to remedy it developed its true cause. The error produced must be much less than the average error of observation; but it is systematic, and cannot easily be rectified by correction; and it should be avoided by placing the deflector, as I have now done, so as to throw the image to the north or to the south of the original star, instead of to the east. Thus placed, the shading remains uniform during the observation, and has no effect upon the result.

The deflector, with the use of the full aperture, I have found much more convenient for faint stars than the wedge, being free from illumination-error, and allowing a wider range in observation; and I have therefore for the last year or two used the deflector exclusively in photometric work.

New Variable. In 1886, the fluctuation of DM. +20°2970, near *Arcturus*, attracted my attention, and I have made 111 photometric observations, in order to determine its period. Adopting as the epoch a minimum observed by Yendell in April, combining it with one observed by myself in July, and confirming by a variation noted in 1886, I have derived the period of 2.6052 days. From 42 observations distant from the computed minima, I obtained the normal 8M.08, ranging from 7M.44 to 8M.39. From 47 observations near the minima, the hour not being noted until recently, I obtain the minimum 8M.48, ranging from 8M.26 to 8M.98; but the only observation at the minimum was 8M.59. Of the remaining 22 observations, 7 represent an average of 8M.64, only partially explained; 2 are 8M.05, probably at least two hours before the minimum; and 13 are perhaps affected by a neighboring minimum, although not near enough to be included. There is much fluctuation in several of the comparison-stars; and this star appears to fluctuate irregularly also. Yet the mean brightness of the star does not appreciably change from year to year, and there is a well-marked depression of the *Algol*-type, amounting to at least half a magnitude, lasting perhaps four hours, with a period of about 2.6052 days, which largely explains its varying brightness.

Since writing the preceding paragraph, I have made additional observations, which indicate the necessity for a sine-correction.

R Comae. Assuming as a maximum my observation of 1884 Aug. 11, the period is lengthening, and early observations are important; since the time of maximum has now nearly reached its eastern elongation, and it will be at least thirty years before the maxima will be visible in the morning twilight as far from the sun as at present. The star *H*, DM. +20°2683, is not a suitable comparison-star, being fluctuating. *L*, DM. +20°2676, 8ᴹ.50, is nearer, and more reliable.

[The column headed W expresses the estimated weight of my determination of the time of the phase observed.]

RESULTS OF OBSERVATIONS.

No.	Star	Phase	Observed Date		E	Corr.	W	Remarks
			Julian	Calendar				
				1894				
2691	*T Canis min.*	Max.	2851	Jan. 22	27	0	–	Interval too long for accuracy
2735	*U Canis min.*	Min.	2946 :	Apr. 27	13	+31	1	Perhaps later
2742	*S Geminorum*	Max.	2832	Jan. 3	52	– 2	–	Yendell's min. My obs. began too late
(2903)	*— Cancri*	–	–	–	–	–	–	Peters's variable. Nothing decisive yet
2976	*V Cancri*	Min.	2882	Feb. 22	31	–13	3	
3060	*U Cancri*	Max.	2893	Mar. 5	49	+20	5	Period shortening more slowly
3170	*S Hydrae*	Max.	2961	May 12	53	–19	5	Obs. began nearly at preceding min.
3477	*R Leonis min.*	Min.	2867 :	Feb. 7	29	0	0	Prediction from elements
3493	*R Leonis*	Max.	2959	May 10	160	–22	7	
3567	*V Leonis*	Max.	2919	Mar. 31	16	–11	5	Clouds prevented verification of light-curve. See *A.J.*256
3881	*V Hydrae*	Min.	3000 :	June 20	14	0	0	Approx. prediction ; obs. not satisfactory
3890	*W Leonis*	Max.	3116	Oct. 14	21	–	–	Prediction ; not visible until August by my elements
3994	*S Leonis*	Max.	2897	Mar. 9	64	–	–	Prediction ; obs. indicate positive correction
"	"	Min.	2967 :	May 18	65	–	–	Prediction ; obs. indicate negative correction
4315	*R Comae*	Max.	3048.1	Aug. 7	38	+28	9	Period appears to be now about 364 days.
4492	*Y Virginis*	Min.	2952 :	May 3	19	–	–	Prediction ; invisible for at least two months
4596	*U Virginis*	Max.	2911	Mar. 23	49	–10	3	
4816	*V Virginis*	Max.	2963	May 14	50	–18	5	Fluctuation and flat curve
4826	*R Hydrae*	Min.	3003	June 23	3	–	0	Prediction ; lost in the west
4847	*S Virginis*	Max.	2963	May 14	41	+ 3	5	

INDIVIDUAL OBSERVATIONS.

2691 *T Canis minoris.*

Julian	Calendar	Mag.
d	1894	
2834	Jan. 5	10.4]
2836	7	12.0
2854	25	11.2
2856	27	11.4
2860	31	11.7
2861	Feb. 1	12.32_2
2891	Mar. 3	12.0
2911	23	11.7
2925	Apr. 6	11.8
2941	22	11.6
2949	30	11.8
2957	May 8	11.3]

2735 *U Canis minoris.*

Julian	Calendar	Mag.
2887	Feb. 27	10.8
2911	Mar. 23	12.6
2925	Apr. 6	12.9
2941	22	13.0
2944	25	13.0]
2949	30	13.0]
2957	May 8	12.4]

2742 *S Geminorum.*

Julian	Calendar	Mag.
d	1894	
2834	Jan. 5	9.0
2836	7	9.25_2
2843	14	9.24_2
2846	17	9.86_2
2854	25	9.45_2
2856	27	9.52_2

(2903) *— Cancri.*

Julian	Calendar	Mag.
2925	Apr. 6	13.19
2944	25	13.0
2978	May 29	13.0:

2976 *V Cancri.*

Julian	Calendar	Mag.
2870	Feb. 10	12.0
2884	24	12.2
2891	Mar. 3	11.9
2911	23	11.4

3060 *U Cancri.*

Julian	Calendar	Mag.
2843	Jan. 14	10.2]
2854	25	12.0

3060 *U Cancri*—Cont.

Julian	Calendar	Mag.
d	1894	
2860	Jan. 31	11.0
2870	Feb. 10	10.41_2
2887	27	10.10_2
2895	Mar. 7	10.09_2
2911	23	10.30_2

3170 *S Hydrae.*

Julian	Calendar	Mag.
2836	Jan. 7	11.7
2860	31	11.7
2870	Feb. 10	11.4
2895	Mar. 7	9.4
2911	23	8.99_2
2940	Apr. 22	7.91_2
2957	May 8	7.50_2
2975	26	7.46_2
2978	29	7.54_2
2983	June 3	7.94_3

3477 *R Leonis minoris.*

Julian	Calendar	Mag.
2862	Feb. 2	12.7]
2870	10	12.1]

3477 *R Leon.min.*—Cont

Julian	Calendar	Mag.
d	1884	
2884	Feb. 24	12.7]
2895	Mar. 7	12.6

3493 *R Leonis.*

Julian	Calendar	Mag.
2922	Apr. 3	8.11_2
2935	16	7.24_2
2945	26	7.15_2
2957	May 8	6.31_2
2975	26	7.22_2
2983	June 3	7.16_2
2988	8	7.30_2

3567 *V Leonis.*

Julian	Calendar	Mag.
2914	Mar. 26	9.8
2915	27	8.66_2
2922	Apr. 3	8.80_2
2928	9	9.8
2934	15	8.61_2
2941	22	9.68_2

3881 *V Hydrae.*

Julian	Calendar	Mag.
2941	Apr. 22	7.3

3881 *V Hydrae*—Cont.

Julian	Calendar	Mag.
d	1894	
2957	May 8	7.9
2961	12	7.17_2
2975	26	6.64
2976	27	7.48_2

3890 *W Leonis.*

Julian	Calendar	Mag.
2895	Mar. 7	13.1]
2928	Apr. 9	13.1]
2948	29	13.1]
2978	May 29	13.2]
3007	June 27	12.4]

3994 *S Leonis.*

Julian	Calendar	Mag.
2870	Feb. 10	10.3
2895	Mar. 7	10.53_2
2911	23	11.24_2
2928	Apr. 9	12.1
2943	24 to	
-3001	June 21	12.7]
	4 dates	

4315 *R Comae.*

Julian	Calendar	Mag.
d	1894	
2976	May 27	12.0]
2988	June 8	12.0]
3001	21	12.6
3007	27	11.9
3013	July 3	11.7
3017	7	12.46
3030	20	10.67_2
3034	24	10.48
3037	27	10.09_3
3038	28	10.01_2
3046	Aug. 5	9.56_3
3047	Aug. 6	8.50_2
3048	7	9.00_2
3050	9	9.23_3
3051	10	9.13_3
3052	11	9.95_3

4492 *Y Virginis.*

Julian	Calendar	Mag.
2914	Mar. 26	12.5]
2983	June 3	12.0
3007	27	10.6

4596 *U Virginis.*

Julian	Calendar	Mag.
d	1894	
2895	Mar. 7	9.0
2915	27	8.14_2
2922	Apr. 3	8.50_2

4816 *V Virginis.*

Julian	Calendar	Mag.
2922	Apr. 3	11.5
2943	24	8.8
2944	25	8.76_2
2949	30	8.65
2957	May 8	8.69_2
2976	27	9.00_2
2983	June 3	8.49_2
2988	8	8.79_2
2997	17	9.2
2998	18	8.99_2

4826 *R Hydrae.*

Julian	Calendar	Mag.
2941	Apr. 22	6.9
2957	May 8	9.4
2962	13	9.6
2976	27	11.2
2983	June 3	10.04_2
3002	June 22	11.05_2

4847 *S Virginis.*

Julian	Calendar	Mag.
2922	Apr. 3	9.7
2935	16	8.85_2
2943	24	8.0
2948	29	8.97_2
2957	May 8	8.10_2
2959	10	7.47_2
2962	13	7.58_2
2976	27	8.12_2

The above observations for 2691, 2735, 2742, 3060, 3994, 4492 and 4596, are continued from *A.J.* 308.

The above discovery by Mr. PARKHURST, that DM. +20°2970 is a variable of the *Algol*-type, being confirmed by Mr. YENDELL below, permits the definitive notation, 5144 *Y Bootis*, for this star; whose place for 1900 is, $\alpha = 14^h\ 17^m\ 22^s$, $\delta = 20°\ 15'.8$ approximately. — ED.

ON THE VARIABILITY OF DM. +20°2970,

α, $14^h\ 15^m\ 16^s.5$; δ, $+20°\ 28'.3$ (1855).

BY P. S. YENDELL.

In August, 1893, my attention was called to the probable variability of this star by PARKHURST, of Brooklyn, N.Y.

Although the star was then so far west that all observations were, of necessity, made in the evening twilight, about twenty-five were secured before its approach to the sun put an end to them. It was taken up early this year, and from 1894 March 23 to July 24, I have observed the star about eighty times.

The observations of 1893 indicated a variation of about half a magnitude, and, upon assembling them, the light-curve, roughly indicated, bore a striking resemblance to that of the stars of the *Algol*-type. Being made on a bright sky, however, these observations are not directly comparable, either with my own of the present season, or with PARKHURST's, but show a pretty constant difference of about eight-tenths of a magnitude brighter than either, while our magnitude-limits during the present season show a remarkable agreement.

The behavior of the star during the present season, while presenting certain very puzzling anomalies, gives a strong general indication of the *Algol*-type of variation, and I have obtained one well observed minimum, showing unmistakably the characteristics of that type. Of nearly eighty observations, which make up the present season's work to the date of this paper, thirty-nine are within a single step of the mean normal brightness, and the occasions on which the star was observed below this mean show a decided preference for intervals of five, eight, and ten days.

On 1894, April 29, an actual *Algol*-type minimum was observed, nine observations being made, from $8^h\ 0^m$ to $11^h\ 20^m$, local Mean Time. The minimum was definitely indicated at $10^h\ 13^m$, which is probably not more than ten minutes wrong, and at the last observation, a marked increase had been made certain of. Other less exactly defined minima have been observed on May 12 and July 24.

Sufficient material has not yet been accumulated for any approximation to a mean light-curve, but the principal part of the decrease appears to occupy about two hours, and the increase may be still more rapid. Combining my observations of this year with the minimum of April 29.426 as a principal epoch, I find a period of $2^d.6052$, which satisfies the best determined dates fairly well; the last two decimals, however, are very uncertain. The mean normal brightness indicated by my observations is $8^M.1$; the minimum reached on April 29 was $8^M.58$.

Dorchester, Mass., 1894 *July* 28.

MAXIMA AND MINIMA OF LONG-PERIOD VARIABLES,

BY J. A. PARKHURST.

The following observations were made, as my previous series were, with a 6.2-inch Brashear reflector, the aperture being reduced to 3.2 inches for stars brighter than 9^M. The magnitudes are expressed in the historic scale.

678. *U Persei.*

A continuous watch has been kept on this star since the minimum 1893 Nov. 15. From that date till 1894 July 8, 42 observations give a maximum $7^M.5$, 1894 May 3. The decline since the maximum has been a little more rapid than the rise.

1981. *S Camelopardalis.*

This star has fluctuated to such an extent as to render the date of its maximum somewhat uncertain, though 36 observations from 1893 Nov. 2 to 1894 July 9 indicate maxima 1894 April 7 and 30, each of $7^{M}.7$. The decline since those dates has been quite regular.

2258. *V Aurigae.*

I have 21 observations between 1894 Jan. 29 and May 29. They indicate a minimum at $11^{M}.3$ 1894 April 16.

3825. *R Ursae Majoris.*

This star has been observed continuously for more than a year. Since the maximum 1893 Oct. 14, 41 observations give a minimum, $12^{M}.6$, 1894 April 24.

4511. *T Ursae Majoris.*

A minimum 1894 May 10, $12^{M}.8$, is indicated by 27 observations between 1894 Jan. 6 and July 6.

4557. *S Ursae Majoris.*

I have 28 observations from 1893 Dec. 15 to 1894 June 11. They yield a minimum at $11^{M}.5$ 1894 April 15.

4596. *U Virginis.*

Only 8 observations of this star were secured this year, beginning 1894 Mar. 1, and ending May 31. They are, however, quite accordant, and indicate a maximum at $8^{M}.0$ Mar. 30.

4847. *S Virginis.*

Between 1894 Mar. 11 and July 21, I observed this star 17 times. A maximum at $7^{M}.8$ is indicated 1894 May 22. The rise was much more rapid than the decline.

5157. *S Bootis.*

This star has been observed frequently for more than a year. From 1894 Jan. 29 to July 8, 24 observations yield a maximum at $8^{M}.0$, 1894 May 14.

5190. *R Camelopardalis.*

This star passed a minimum at $12^{M}.6$ 1894 June 14. I have 24 observations, extending from Jan. 24 to July 23.

5338. *U Bootis.*

A sharply defined minimum at $12^{M}.3$ is indicated for 1894 June 9, by 18 observations, between 1894 Mar. 31 and July 6.

5887. *V Ophiuchi.*

My watch on this star began too late to furnish an accurate value of the date of maximum which is indicated for 1894 April 17. I have 2 observations before that date, April 11 and 16, and 9 after it, extending to July 23. The magnitude at maximum was $6^{M}.9$.

6207. *Z Ophiuchi.*

My observations of this new variable began 1894 Mar. 6, at which time it was $8^{M}.3$. It rose slowly to a maximum, $7^{M}.5$, 1894 April 30, and then fell still more slowly till at the last observation, July 23, it was about $9^{M}.3$. I have 19 observations in all. The light-curve is quite flat near the maximum, which may have occurred 10 days earlier.

Marengo, Ill., 1894 *July* 24.

NEW SHORT-PERIOD VARIABLE.

BY A. W. ROBERTS.

Cord. Z.C. XVI, 3572; $16^{h}\ 50^{m}\ 10^{s}$, $-33°\ 24'.4$ (1875).

The variation of this star was discovered in April. The period is 6.15 days. The ascending period is performed in about two days. The limits of variation are $6^{M}.8$ and $7^{M}.6$. In the Cordoba Zone-Catalogue the magnitude is noted as $7^{M}.0$.

Alice, South Africa, 1894 *July* 5.

NOTE ON THE VARIABLE STAR CORDOBA GEN. CATAL. 22855,

BY W. W. CAMPBELL.

While observing the WOLF-RAYET star Cord. G.C. 22838 on 1893 June 8, 9 and 27, I noticed that the 7^{M} star Cord. G.C. 22855, shown on my chart of that region, could not be seen in the 4-inch finder. Suspecting the star to be a variable, I looked for it again on 1894 June 22, when it was of the 7th magnitude. It was fainter than the $9^{M}.5$ in June, 1893. After making the observations I found that Mrs. FLEMING announced its variability in 1890 (see *A.N.* 2997), and that it is contained in Dr. CHANDLER'S list of unconfirmed stars.

Mt. Hamilton, 1894 *Aug.* 20.

The above confirmation by Prof. CAMPBELL now permits the definitive notation 6050 *RS Scorpii*; and the star may be removed from the "Unconfirmed List" of the Catalogue, *A.J.* 300. Place for 1855, $\alpha = 16^{h}\ 45^{m}\ 7^{s}$, $\delta = -44°\ 51'.6$; for 1900 $\alpha = 16^{h}\ 48^{m}\ 22^{s}$, $\delta = -44°\ 56'.3$. — ED.

ANNOUNCEMENT OF NEW VARIABLE.

The Rev. T. E. Espin announces (Wolsingham Observatory, Circular No. 39) that "the star DM. $+50°2251$, $\alpha = 16^h\ 1^m.5$, $\delta = +50°\ 47'$ (1900), is variable."

CONFIRMATION OF VARIABILITY OF (6894) —*LYRAE*,

By HENRY M. PARKHURST.

The above star, announced by Espin, is certainly variable. On June 8 I could not see it; on July 7 saw it faintly; on Aug. 7 it had nearly reached 10^M.

The above confirmation permits the definitive notation 6894 *S Lyrae*; and the star may be removed from the "Unconfirmed List," Table III of the Supplement to Second Catalogue, *A.J.* 319. — Ed.

THE SPECTRUM OF COMET *b* 1894,

By W. W. CAMPBELL.

The spectrum of this comet was observed here on six evenings with the 36-inch equatorial and Brashear spectroscope.

Visual Observations. The continuous spectrum, and the yellow, green and blue bands, were present, having about their usual relative intensities. With a narrow slit I was able to see a bright line at $\lambda 563$, terminating the yellow band; another bright line at $\lambda 474$, terminating the blue band; and two bright lines in the green band were measured at $\lambda 5163.5$ and $\lambda 5124$. These four lines were undoubtedly the edges of carbon bands at wave-lengths 5635, 4737, 5165.3 and 5129.

The bands were observed with the slit set at different widths. The effect of slit-width upon the appearance of the bands seemed to agree in every respect with that pointed out by Professors Vogel and Kayser.

Photographic Observations. The spectrum was photographed with a dense 60° prism, and a $10\frac{1}{2}$-inch camera lens. One negative, exposed about $1^h\ 45^m$ on May 1, recorded six bright lines. Another plate was exposed 2^h on May 2, and $2^h\ 30^m$ on May 3, or $4^h\ 30^m$ on the two evenings. It shows at least fifteen bright lines, and the unresolved band at $\lambda 47$. A third negative was exposed $3^h\ 30^m$ on May 9, and $3^h\ 40^m$ on May 10, or $7^h\ 10^m$ on the two nights. It shows at least twenty-two bright lines.

The wave-lengths of the bright lines photographed are tabulated below. Those in the third column were obtained from accurate measures and reductions of the third negative; and they have been adopted as the wave-lengths of the corresponding lines shown on the first and second negatives. The chemical origin of the bright lines is given in column four.

May 1	May 2, 3	May 9, 10	Chemical Origin	Descript'n of comet bright lines
4736	4736	4735.8	Carbon 4737.2	v. bright
–	4716	4716.0	" 4715.3	v. bright
–	–	4697.4	" 4697.6	v. bright
–	–	4681	" 4685–78	v. bright broad[1]
very	broad	band	Carbon	[2]
4367	4367	4366.6	Cyanogen flame?	bright
–	–	4350.6	. . . .	faint
–	–	4333.3	. . . .	v. faint
4313	4313	4312.6	Cyanogen flame?	bright
–	4299	4299.1	. . . .	bright
–	–	4233	. . . .	v. faint
4214	4214	4213.8	Cyanogen 4216.1	bright
–	4196	4196.7	Cyanogen 4197.2	bright
–	–	4124	. . . .	v. faint
–	4097	4097.4	. . . .	faint
–	4071	4070.7	. . . .	bright[3]
–	4051	4050.5	. . . .	bright
–	4041	4040.9	. . . .	bright
–	4016	4015.7	. . . .	bright, broad[4]
–	3987	3987	. . . .	faint
3880	3880	3879.5	Cyanogen 3883.6	[5]
3869	3869	3869.4	Cyanogen 3871.5	v. bright

[1] Possibly double.
[2] Rest of band is unresolved
[3] Probably double at 4074, 4068.
[4] Probably double at 4019, 4013.
[5] Brightest line on negatives.

A comparison of this spectrum with that of Comet *b* 1893* shows that the two spectra were identical. Twenty-five bright lines were observed in the spectrum of Comet *b* 1894, and thirty in that of Comet *b* 1893. The excess of five faint lines in the latter spectrum is plainly attributable to the greater brightness of Comet *b* 1893.

The principal lines in these spectra are seen to be due to the presence of carbon and cyanogen in the comets, but the origin of several of the fainter lines is still unknown.

Mt. Hamilton, 1894 *Aug.* 20.

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* See *Publications Astronomical Society of the Pacific*, Vol. V., pp. 208 210.

OBSERVATIONS OF COMET *b* 1894,

MADE AT THE DUDLEY OBSERVATORY,

BY LEWIS BOSS.

1894 Albany M.T.	*	No. Comp.	☄ — *		☄'s apparent		log *p*Δ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
June 21 10 46 13	6	5	−4 42.45	+3 47.7	11 50 53.76	+42 53 16.1	9.756	0.499
30 9 25 7	7	5	−3 59.85	+0 54.1	12 8 6.68	+43 24 3.3	9.707	0.298
July 4 10 33 35	8	7	−2 27.38	+1 17.0	12 15 34.10	+43 30 29.2	9.767	0.527
5 9 51 33	8	7	−0 41.04	+2 16.7	12 17 20.43	+43 31 28.9	9.742	0.413

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
6	11 55 34.37	+1.84	+42 49 23.1	+5.3	W.B. 1048
7	12 12 4.76	+1.77	+43 23 4.2	+5.0	W.B. 198
8	12 17 59.72	{+1.76 +1.75}	+43 29 7.5	{+4.7 +4.7}	Bonn VI. 43°2215

OBSERVATIONS OF COMET *b* 1894,

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

1894 Cincinnati M.T.	*	No. Comp.	☄ — *		☄'s apparent		log *p*Δ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
July 22 9 3 29	1	8	+0 28.05	−2 53.8	12 47 26.05	+43 25 16.6	9.757	0.307
22 9 16 23	2	8	−0 54.67	+4 18.1	12 47 27.23	+43 25 14.0	9.767	0.357
27 9 29 52	3	12	+1 45.90	−1 32.7	12 56 10.56	+43 17 41.5	9.782	0.441

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	12 46 56.41	+1.59	+43 28 6.8	+3.6	Bonn VI. +43°2266
2	12 48 20.31	+1.59	+43 20 52.3	+3.6	Bonn VI. +43°2270
3	12 54 23.15	+1.51	+43 19 11.0	+3.2	Bonn VI. +43°2285

REMARKS. Comet was very faint on both evenings. It was again seen on August 3, but was too faint to measure.

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VARIATION OF (3416)* —*VELORUM* AND (5949) —*ARAE*,

BY A. W. ROBERTS.

During the last two years two *Algol*-variables have been discovered in the Southern hemisphere, one at Lovedale in 1892, and the other at the Cape Royal Observatory in February of the present year. The first star is Lacaille 6887 [No. (5949) in CHANDLER's Catalogue.] Its period is $4^d\ 10^h\ 12^m\ 42^s$, the duration of variation being about $10^h\ 20^m$.

Most of the observations have already been reduced, but the star being still well suited for prolonged observation, it has been thought best to delay publication for a little.

Concerning the other star, Cordoba General Catalogue 13052, $\alpha = 9^h\ 28^m\ 30^s.6$, $\delta = -44°\ 39'\ 19''$ (1875), [No. (3416) of CHANDLER's Catalogue], the same reason for delay does not exist. It is now so low down in the west that, for the next three or four months, observations will of necessity be few; apart therefore from the advisableness of confirming variation as soon as possible, the present time is not unsuitable for discussing the observations made here from April to July.

Although Dr. GILL most kindly communicated to me its variation early in February, a combination of circumstances —cloudy weather chiefly—hindered my obtaining good observations for some time; yet the observations made during February and March were sufficient to certify the nature of the star's variation. After March the weather became more settled, and observations were made more regularly.

It would burden the present paper unduly to give all the observations made here, and so only those are given in detail which are of importance in determining the form of the light-curve, that is, those made during a varying phase.

All the other observations indicate that for $5^d\ 7^h$ the star's light remains constantly at $7^M.85$. Its type is therefore unquestionable.

Several of the minima took place at full moon, 5 light-periods being performed in almost exactly a synodical month, and although a large number of observations were made at these times they are not included in the discussion, as the effect of moonlight upon magnitude is still very uncertain.

Method of Observation. Two instruments are used for the observation of variable stars, a good 1-inch theodolite, and a 2½-inch telescope. Two eyepieces are always used, the one a direct, and the other a reversing eyepiece. The mean of both is the observation recorded. The two standard magnitudes used are 6.8 and 9.3. The former magnitude is considered to be that of a star just on the threshold of visibility on a clear evening; the latter magnitude is that just seen, and no more, in the 1-inch theodolite. The same comparison-stars are always used, and their magnitudes are estimated by a method of sequences *inter se*, each step being, as nearly as possible, made equal to $0^M.1$. In the present case the sequences were made upwards from $9^M.3$, and consequently the values given represent actual magnitudes, and not steps merely.

It may not be out of place to enter more fully into the necessity for, and the importance of, the method I have adopted of observing first direct, and then reverse.

The disturbing influence of position upon magnitude is well known among variable-star observers. Dr. GOULD has on several occasions directed the attention of observers to this subjective source of error. Prof. PICKERING has discussed the matter in his "Harvard Photometry." Its existence is therefore real and active; its effect may be traced in every catalogue of "suspected" variables; it is to light-measurement what instrumental flexure, eccentric movement, is to meridian-observation.

To eliminate this source of error is therefore a necessity, and I think there is no method more simple or handy than taking two observations, one of them being in a reverse position from the other.

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* This confirmation by Prof. ROBERTS permits the definitive notation 3416 *S Velorum*; and the star may be removed from the "Unconfirmed List," Table III, of the Supplement to Second Catalogue (*A.J.* 319). This letter is chosen to avoid confusion; although the variation of (3614) (*R*) *Velorum*, of the "Unconfirmed List" of the Second Catalogue (*A.J.* 300), still awaits independent confirmation. — ED.

Before adopting this method, I had thought of having a telescope constructed with a prism in the focus, so that the field could be turned round in any direction. With this instrument four observations would be taken, one in each quadrant.

In taking observations, the position of the head had to be carefully noticed. Thus, for example, the direct-vision eyepiece is very much longer than the reversing one, and the tendency was slightly to twist the head in looking through it, so that the position of the eye with regard to the two eyepieces was not similar. This apparently trifling matter caused a considerable amount of trouble for a time.

The method of reduction from the observed measures may be illustrated by the following tables. In table I, we have ten measures of the variable made on different evenings with the reversing eyepiece. It may be stated that in the reversing eyepiece A.Z.C. IX 2429 was the lowest star in the field, while in the direct-vision eyepiece its position was highest. A glance at direct and reverse measures of this star will abundantly testify to the influence of position; at least in my case.

I. MEASURES MADE WITH REVERSING EYEPIECE.

Date	A.Z.C. 2147	A.Z.C. 2157	A.Z.C. 2301	A.Z.C. 2429	Var.
	M	M	M	M	M
1894 May 25	8.0	8.2	8.4	8.2	7.8
25	8.0	8.1	8.4	8.0	7.8
31	8.2	8.1	8.1	7.8	7.7
June 1	8.1	8.1	8.0	7.9	7.6
2	8.0	8.3	8.2	8.0	7.8
8	8.0	8.2	8.0	7.8	7.7
July 4	8.1	8.2	8.0	7.9	7.7
6	8.1	8.1	8.0	7.9	7.7
8	8.1	8.3	8.1	8.0	7.8
27	8.0	8.2	8.1	7.9	7.7

These measures are not in any way reduced, but are simply put down from the observing sheet.

Table II gives the measures made at the same time with the direct-vision eyepiece. As in Table I the results are unreduced.

II. MEASURES MADE WITH DIRECT-VISION EYEPIECE.

Date	A.Z.C. 2147	A.Z.C. 2157	A.Z.C. 2301	A.Z.C. 2429	Var.
	M	M	M	M	M
1894 May 25	7.8	8.0	8.2	8.5	8.0
25	8.0	8.2	8.4	8.6	7.8
31	7.8	8.0	8.4	8.6	8.1
June 1	7.6	7.9	8.3	8.6	8.0
2	7.8	8.0	8.3	8.6	7.9
8	7.8	8.0	8.3	8.6	7.9
July 4	7.8	8.0	8.5	8.7	7.8
6	7.6	7.8	8.4	8.7	8.0
8	7.8	8.0	8.4	8.7	7.9
27	7.8	8.0	8.4	8.7	8.0

If we now take the mean of these apparently contradictory measures we have Table III.

III. MEAN OF REVERSE AND DIRECT-VISION MEASURES.

Date	A.Z.C. 2147	A.Z.C. 2157	A.Z.C. 2301	A.Z.C. 2429	Var.	Total
	M	M	M	M	M	M
1894 May 25	7.90	8.10	8.30	8.35	7.90	40.55
25	8.00	8.15	8.40	8.30	7.80	40.65
31	8.00	8.05	8.25	8.20	7.90	40.40
June 1	7.85	8.00	8.15	8.25	7.80	40.05
2	7.90	8.15	8.25	8.30	7.85	40.45
8	7.90	8.10	8.15	8.20	7.80	40.15
July 4	7.95	8.10	8.25	8.30	7.75	40.35
6	7.95	7.95	8.20	8.30	7.85	40.15
8	7.95	8.15	8.25	8.35	7.85	40.50
27	7.90	8.10	8.25	8.30	7.85	40.40

The next step is to reduce the measures to the same standard, that is, to make all their totals equal to the mean total of Table III.

TABLE IV. REDUCED RESULTS.

Date	A.Z.C. 2147	A.Z.C. 2157	A.Z.C. 2301	A.Z.C. 2429	Var.	Total
	M	M	M	M	M	M
1894 May 25	7.86	8.06	8.26	8.31	7.86	40.35
25	7.94	8.09	8.34	8.24	7.74	40.35
31	7.99	8.04	8.24	8.19	7.89	40.35
June 1	7.91	8.06	8.21	8.31	7.86	40.35
2	7.88	8.13	8.23	8.28	7.83	40.35
8	7.94	8.14	8.19	8.24	7.84	40.35
July 4	7.95	8.10	8.25	8.30	7.75	40.35
6	7.89	7.99	8.24	8.38	7.89	40.35
8	7.87	8.12	8.22	8.32	7.82	40.35
27	7.89	8.09	8.24	8.29	7.84	40.35

The average error of an observation is $\pm 0^{M}.038$, an amount which is almost identical with that found from an examination of several other variables.

I have dwelt more fully upon this portion of my paper than I had at first intended; but an exposition of the method rigorously adopted in reducing the observations of this star, as well as of all the other variables observed here, is of as much importance as the results obtained from the observations, inasmuch as the results depend to some extent on the method of reduction adopted.

It may be remarked in passing, that if m be the average magnitude of any star in a field of say five or six stars, and m_0 its magnitude at any date obtained by sequences from the other stars, using only a reversing eyepiece, then

$$m - m_0 = x \sin(h+M) + y \sin(2h+N)$$

where h is the hour-angle of the star, and x, y, M, N, values constant for the same star.

The same formula, adding 12 hours to h, will be applicable to magnitudes estimated with a direct-vision eyepiece only. The magnitude of x and y depends on the distance of the star from the center of the field.

Detailed Observations. In determining the magnitudes of the variable the following comparison-stars have been used. The places are for 1875.

A.Z.C. IX Hours	α	δ	Mag.	A.Z.C. IX Hours	α	δ	Mag.
	h m s	° ′ ″			h m s	° ′ ″	
2034	9 25 11	−44 21 37	7.80	2175	9 26 49	−44 56 24	9.15
2126	26 16	44 41 59	8.85	2204	27 17	44 53 1	9.70
2137	26 23	44 54 46	8.95	2207	27 18	45 14 36	8.80
2147	26 34	45 27 24	7.95	–	28 8	44 37 57	9.40
2153	26 36	44 40 57	8.90	2301	28 31	44 57 41	8.25
2157	26 38	45 3 53	8.10	–	29 18	44 42 36	9.15
2174	9 26 49	−44 34 48	9.20	2429	9 30 11	−44 40 29	8.33

The magnitudes of these comparison-stars have been obtained by the method already described. All the times of observation have been reduced to Greenwich mean heliocentric time.

1894 *April* 1.

G.M.T.	Observed	O—C
h m	M	M
5 35	7.83	−0.02
6 35	7.90	+0.05
7 0	7.85	0.00
7 35	7.80	−0.05
8 5	7.86	+0.01
8 35	7.81	−0.04
9 10	7.90	0.00
9 50	7.93	−0.08
10 5	8.03	−0.01
10 35	8.19	+0.06
11 5	8.25	+0.02
11 35	8.45	+0.07
12 5	8.50	−0.08
12 35	8.90	+0.05
13 5	9.10	−0.10

Average error = $\pm 0^{\mathrm{M}}.042$.

1894 *April* 13.

G.M.T.	Observed	O—C
h m	M	M
5 4	7.83	−0.02
5 34	7.85	0.00
6 4	7.92	0.00
6 34	8.10	+0.10
6 51	8.05	+0.01
7 26	8.20	+0.06
7 44	8.25	+0.05
8 4	8.30	+0.01
8 11	8.30	−0.01
8 32	8.40	−0.04
8 39	8.40	−0.09
9 2	8.70	+0.04
9 9	8.65	−0.07
9 34	9.10	+0.14
10 4	9.30	+0.05
10 34	9.20	−0.05
11 26	9.25	0.00
11 31	9.27	+0.02
12 4	9.20	−0.05
12 24	9.25	0.00
12 34	9.20	−0.05
12 49	9.25	0.00
13 19	9.25	0.00

Average error = $\pm 0^{\mathrm{M}}.036$.

1894 *May* 1.

G.M.T.	Observed	O—C
5 3	9.20	−0.03
5 8	9.20	−0.05
5 31	9.25	0.00
5 51	9.30	+0.05
6 36	9.30	+0.05
6 43	9.30	+0.05
6 58	9.30	+0.05
7 3	9.25	0.00
8 3	9.20	−0.05
8 8	9.25	0.00
9 3	9.30	+0.05
10 3	9.25	0.00
10 13	9.20	−0.05
10 48	9.20	−0.05
10 53	9.25	0.00

Average error = $\pm 0^{\mathrm{M}}.032$.

1894 *May* 7.

G.M.T.	Observed	O—C
4 22	9.20	−0.05
5 32	9.20	−0.05
5 52	9.20	−0.05
6 32	9.25	0.00
7 2	9.20	−0.05
7 32	9.20	−0.05
8 2	9.20	−0.05
8 47	9.20	−0.05

Average error = $\pm 0^{\mathrm{M}}.044$.

1894 *May* 25.

G.M.T.	Observed	O—C
4 23	9.25	0.00
4 53	9.30	+0.05
5 48	8.75	−0.08
5 57	8.73	−0.01
6 17	8.60	+0.03
6 38	8.40	−0.03
6 54	8.40	+0.07
7 14	8.35	+0.11
7 31	8.15	−0.03
7 49	8.15	+0.03
8 15	8.10	+0.06
8 40	8.00	+0.02
9 6	7.90	−0.01
9 45	7.90	+0.05
9 58	7.80	−0.05

Average error = $\pm 0^{\mathrm{M}}.042$.

1894 *May* 31.

G.M.T.	Observed	O—C
6 7	8.05	−0.09
6 25	8.00	−0.08
6 47	7.95	−0.07
6 7	7.95	−0.02
6 27	7.90	−0.02

Average error = $\pm 0^{\mathrm{M}}.056$.

NOTE. Night hazy, and observations difficult.

1894 *July* 23.

G.M.T.	Observed	O—C
h m	M	M
4 36	8.25	0.00
4 39	8.30	+0.03
4 43	8.25	−0.04
5 7	8.45	+0.03
5 15	8.50	+0.02
5 22	8.55	+0.02
5 32	8.65	+0.05
5 42	8.70	+0.02
5 46	8.70	−0.01
5 56	8.75	−0.06
6 1	8.75	−0.11
6 6	8.86	−0.05
6 16	9.00	−0.01
6 26	9.10	−0.05
6 36	9.20	−0.05

Average error = $\pm 0^{\mathrm{M}}.037$.

1894 *July* 29.

G.M.T.	Observed	O—C
4 37	8.95	−0.04
4 40	9.05	+0.02
4 41	9.05	+0.01
4 43	9.10	+0.03
4 47	9.15	+0.03
4 49	9.15	0.00
4 50	9.20	+0.04
4 52	9.25	+0.06
4 57	9.25	0.00
5 7	9.25	0.00
5 27	9.25	0.00
5 33	9.25	0.00
5 41	9.25	0.00
5 49	9.25	0.00
5 57	9.25	0.00

Average error = $\pm 0^{\mathrm{M}}.015$.

It has already been stated that only those observations are given which were taken during a minimum-phase.

Measures were made regularly, night after night, but there is no necessity for giving them.

Reduction of Observations. If we regard the variation of this star as due to an eclipse of one star by another, then we may represent the amount of variation as a function of the time.

Thus, let M be the magnitude at a maximum; M_0 the magnitude at any time, t, during the decreasing phase: D the date when the two discs just touch; then

$$M - M_0 = x\,(D-t) + y\,(D-t)^2 + z(D-t)^3 + w(D-t)^4 \ldots \quad (1)$$

As D may be known with fair exactness by a graphical solution, let

$$D = D_1 + \Delta\delta$$

and as $D_1 - t$ will then be known, we may write equation (1) in the form

$$M - M_0 = x(t_1 + \Delta\delta) + y(t_1 + \Delta\delta)^2 + z(t_1 + \Delta\delta)^3 + w(t_1 + \Delta\delta)^4 \tag{2}$$

where $$t_1 = D_1 - t$$

Expanding this equation and making

$$\begin{aligned}
\alpha &= x\,\Delta\delta + y\,\Delta\delta^2 + z\,\Delta\delta^3 + w\,\Delta\delta^4 \;.\;.\;.\;.\\
\beta &= x + 2y\,\Delta\delta + 3z\,\Delta\delta^2 + 4w\,\Delta\delta^3 \;.\;.\;.\;.\\
\gamma &= y + 3z\,\Delta\delta + 6w\,\Delta\delta^2 \;.\;.\;.\;.\\
\delta &= z + 4w\,\Delta\delta \;.\;.\;.\;.\\
\varepsilon &= w + \;.\;.\;.\;.
\end{aligned}$$

equation (2) becomes

$$M - M_0 = \alpha + \beta t_1 + \gamma t_1^2 + \delta t_1^3 + \varepsilon t_1^4 \;.\;.\;.\;. \tag{3}$$

For the ascending period an equation of a similar type may be formed, equation (2) being of course

$$M - M_0 = x(t_1 - \Delta\delta) + y(t_1 - \Delta\delta)^2 + z(t_1 - \Delta\delta)^3 + w(t_1 - \Delta\delta)^4$$

The observations themselves give as the limits of variation, $7^{\mathrm{M}}.85$ and $9^{\mathrm{M}}.25$. We may therefore determine for each evening the values of x, y, z, w; the time D of beginning or end of eclipse; the time of minimum phase, and also the weights of these values. To obtain the most probable period, and the mean probable values of x, y, z, w, is but a step more.

In this way the following elements of this variable were rigorously computed.

	d h m
Period of variation,	5 22 23.4
Descending period,	0 4 18.0
Stationary period at minimum.	0 6 35.0
Ascending period,	0 4 18.0
Stationary period at maximum,	5 7 12.4

	G.M.T. h m
Epoch of commencement of descending phase, 1894 May 1,	0 47
end of descending phase,	5 5
beginning of ascending phase,	11 40
end of ascending phase,	15 58

Law of variation:

$$M - M_0 = 0^{\mathrm{m}}.1622\,t_1 - 0^{\mathrm{m}}.0256\,t_1^2 + 0^{\mathrm{m}}.0133\,t_1^3 + 0^{\mathrm{m}}.0003\,t_1^4$$

t_1 being the time to, or after, minimum.

The form of the light-curve can best be seen by reducing all the observations given in this paper to the minimum of 1894 May 1. It may specially be noticed here that a secondary maximum does not appear, the fall and rise being quite regular. Indeed, I think the "secondary maximum" is often made a good excuse for poor observations. Frequently what has apparently seemed a decided wave in a curve has disappeared with more careful reduction.

Observations Reduced to 1894 May 1.

G.M.T.	M_0	M_0-M_c	G.M.T.	M_0	M_0-M_c	G.M.T.	M_0	M_0-M_c	G.M.T.	M_0	M_0-M_c
h m	M	M	h m	M	M	h m	M	M	h m	M	M
−2 28	7.83	−0.03	+3 54	8.55	+0.02	+5 16	9.25	0.00	+ 9 9	9.20	−0.05
1 28	7.90	+0.05	4 2	8.50	−0.08	31	9.25	0.00	9 39	9.20	−0.05
1 3	7.85	0.00	4	8.65	+0.05	36	9.25	0.00	10 3	9.25	0.00
−0 28	7.80	−0.05	12	8.70	+0.04	42	9.25	0.00	13	9.20	−0.05
+0 2	7.86	+0.01	14	8.70	+0.02	44	9.20	−0.05	24	9.20	−0.05
14	7.83	−0.02	18	8.70	−0.01	50	9.25	0.00	48	9.20	−0.05
32	7.81	−0.04	19	8.65	−0.07	51	9.30	+0.05	50	9.25	0.00
0 44	7.85	0.00	28	8.75	−0.06	58	9.25	0.00	10 53	9.25	0.00
1 7	7.90	0.00	32	8.90	+0.05	5 59	9.20	−0.05	11 20	9.30	+0.05
14	7.92	0.00	33	8.75	−0.11	6 6	9.25	0.00	12 15	8.75	−0.08
42	8.10	+0.10	38	8.86	−0.05	36	9.30	+0.05	24	8.73	−0.01
1 47	7.93	−0.08	44	9.10	+0.14	36	9.25	0.00	12 44	8.60	+0.03
2 1	8.05	+0.01	46	8.95	−0.04	43	9.30	+0.05	13 5	8.40	−0.03
2	8.03	−0.01	48	9.00	−0.01	44	9.27	+0.02	21	8.40	+0.07
32	8.19	+0.06	49	9.05	+0.02	6 58	9.30	+0.05	41	8.35	+0.11
36	8.20	+0.06	50	9.05	+0.01	7 3	9.25	0.00	13 58	8.15	−0.03
2 54	8.25	+0.05	52	9.10	+0.03	9	9.20	−0.05	14 10	8.05	−0.09
3 2	8.25	+0.02	56	9.15	+0.03	14	9.20	−0.05	16	8.15	+0.03
8	8.25	0.00	58	9.10	−0.05	29	9.20	−0.05	28	8.00	−0.08
11	8.30	+0.03	58	9.15	0.00	34	9.25	0.00	42	8.10	+0.06
14	8.30	+0.01	4 59	9.20	+0.04	44	9.20	−0.05	14 50	7.95	−0.07
15	8.25	−0.04	5 1	9.25	+0.06	7 59	9.25	0.00	15 7	8.00	+0.02
21	8.30	−0.01	2	9.10	−0.10	8 3	9.20	−0.05	10	7.95	−0.02
32	8.45	+0.07	3	9.20	−0.03	8	9.25	0.00	30	7.90	−0.02
39	8.45	+0.03	6	9.25	0.00	9	9.25	0.00	15 33	7.90	−0.01
42	8.40	−0.04	8	9.20	−0.05	29	9.25	0.00	16 12	7.90	+0.05
44	8.50	+0.02	8	9.20	−0.05	8 39	9.20	−0.05	+16 25	7.80	−0.05
+3 49	8.40	−0.09	+5 14	9.30	+0.05	+9 3	9.30	+0.05			

Interpretation of Results. The natural explanation of the variation of this star is, that here we have the opposite of what we have in the case of *Algol*. *Algol* is a bright star with a dark companion. This variable is a dark central star, with a brighter, but much smaller companion, revolving round it. The magnitude of the primary is $9^{\rm M}.25$, of the companion about $8^{\rm M}.05$. When the star is at a minimum we have the light of the primary only, and the variable remains for over six hours at $9^{\rm M}.25$. At a maximum we have the combined light of both stars, that is, $7^{\rm M}.85$.

Considering the eclipse as a central one the ratio of the two diameters will be as 43 : 109.

The assumption that the eclipse is a central one gives us also the relation between the diameters and the distance that separates the two stars, for it is evident that if the smaller star takes 10.9 hours to pass across the primary, and 142.4 hours to describe its orbit, then the diameter of the larger star cannot be less than one-half the distance between the two stars.

It is much to be regretted that the star cannot be passed under the scrutiny of the spectroscope. Such an examination would yield a most valuable train of facts, and would raise probable results into actual knowledge. It is to be hoped that ere long we will have in the southern hemisphere a spectroscope, so adapted, and so powerful, that in half a dozen nights we will have settled, without the prospect of a doubt, the motions of this peculiar binary system; and above all, the motions, relative masses, distances, and hence parallax of $\alpha_2\,\alpha_1$ *Centauri*.

When this explanation of the variation of this star occurred to me, I bethought me of seeing how far the theory of an eclipse, such as I have indicated, would be met by the law of variation resulting from a least-square solution of the different observations.

It was necessary for such an investigation that the light-ratio be known as accurately as possible. I am certain most observers will agree with me that the present accepted value 2.512 is too small.

It certainly takes a group of at least three ninth magnitude stars to give the same light as an eighth magnitude star.

With the very inadequate means at my disposal—a sextant on an altazimuth stand—I made some observations towards obtaining a ratio that would fit better in with facts. I brought two stars into the same field, and estimated their magnitudes: then by the movements of the sextant, superimposed them on one another, and again noted the resultant magnitude. This was done several times, and the results obtained gave as the light-ratio 3.3. At some more convenient time I hope to take up this question again, for it is one which will have more than a mere theoretical value in the discussion of short-period variation.

Taking 3.3 as a probable value of the light-ratio, we find that at a maximum the combined light of both stars ($7^{\rm M}.85$) is 5.32 times the light of the central star alone ($9^{\rm M}.25$); that is, the companion-star is 4.32 times brighter than the primary. As the smaller star moves behind the larger, it becomes an easy geometrical problem to ascertain the amount of eclipse at any time. And from the light-ratio, 3.3, it is a simple matter to convert the amount of light into magnitudes. The following table gives the amount of light given out by the two stars at intervals of $30^{\rm m}$ after the end of full eclipse, and the corresponding value in magnitudes. Column 4 gives the magnitudes as obtained from the actual light-curve; and column 5 gives the correspondence between the two.

Time after min.	Amount of light emitt'd by both stars	Amount expressed in magnitudes	Observed magnitude	Residuals
h m		M	M	M
0 0	1.00	9.25	9.25	+0.00
0 30	1.34	9.00	8.88	+0.12
1 0	1.89	8.72	8.60	+0.12
1 30	2.50	8.48	8.40	+0.08
2 0	3.14	8.29	8.24	+0.05
2 30	3.75	8.14	8.14	+0.00
3 0	4.32	8.02	8.05	−0.03
3 30	4.85	7.93	7.97	−0.04
4 0	5.22	7.88	7.89	−0.01

It is possible that, when the light-ratio is more accurately known, the residuals will be less persistent in sign; however, it seems to me that the correspondence between theory and observation is close enough to warrant our accepting the explanation offered as a true interpretation of the facts observed.

I would desire to acknowledge my indebtedness to Dr. Gill for early information concerning this star, and for the positions of two of the comparison-stars.

Lovedale, South Africa, 1894 *Aug.* 1.

NOTE ON ACCOUNTING FOR THE SECULAR VARIATIONS OF THE ORBITS OF *VENUS* AND *MERCURY*.

By SIMON NEWCOMB.

The study of the secular variations of the orbits of the four inner planets, as derived from observation, has led me to the conclusion that the perihelion of *Mercury* is not the only element the secular variation of which cannot be satisfactorily represented by existing theory. The motion of the node of *Venus* cannot be explained except by supposing errors of observation which do not seem admissible, while the motions of the eccentricity and node of *Mercury* also deviate suspiciously from the results of any probable values of the masses of the disturbing planets.

These anomalies cannot be simultaneously explained either by an intra-mercurial zone of planets, by the action of matter reflecting the zodiacal light, or by a deviation of gravitation from the usually accepted law. The uncertainty as to the mass of *Mercury* makes the construction even of a working hypothesis difficult; but, apart from all considerations of probabilities, *a priori*, the hypothesis which best represents observations is that of a ring of planetoids of small eccentricity a little outside the orbit of *Mercury*, and a little more inclined to the ecliptic. The total mass of the ring may range from one-fiftieth to, perhaps, one three-hundredth of the mass of *Venus*, according to its distance from *Mercury*.

Until I have made a more careful investigation of the subject, including a determination of the probable elements of the hypothetical ring, it will be impossible to decide whether the results of the hypothesis are such as to counterbalance its extreme improbability.

EPHEMERIDES OF LONG-PERIOD VARIABLES FOR 1895,

By S. C. CHANDLER.

The following tables of maxima and minima of variables of long period have been calculated from the elements of the Second Catalogue, and the Supplement (*A.J.* 300 and 319). To save repetition reference is made to the remarks and explanations accompanying the ephemeris for 1894 (*A.J.* 308), all of which apply equally here.

MAXIMA, 1895.

		January
806	*o* Ceti	13
845	*R* Ceti	21
906	*R* Trianguli	19
1222	*R* Persei	26
1582	*S* Tauri	28
1623	*T* Camelopard.	7
1717	*V* Tauri	8
1981	*S* Camelopard.	6:
2583	L_2 Puppis	13
2684	*S* Canis min.	15
3567	*V* Leonis	10
4521	*R* Virginis	3
6903	*T* Sagittarii	29
7450	*V* Aquarii	24
8591	*V* Cephei	12
		February
466	*U* Piscium	24
494	*R* Sculptoris	6
513	*R* Piscium	27
2100	*U* Orionis	27
2539	*R* Canis min.	3
3170	*S* Hydrae	12
3637	*S* Carinae	24
4816	*V* Virginis	7
5095	*R* Centauri	15
5237	*R* Bootis	12
5583	*X* Librae	11
5770	*R* Herculis	17
5856	*W* Ophiuchi	16
5887	*V* Ophiuchi	7
5903	*Y* Scorpii	28
6624	*T* Serpentis	5
6921	*S* Sagittarii	22
6943	*T* Sagittae	24:
7571	*V* Capricorni	26
7577	*X* Capricorni	4
7909	*S* Piscis aus.	27
		March
1771	*R* Leporis	22
2976	*V* Cancri	16
4492	*Y* Virginis	3
4557	*S* Ursae Maj.	20
5157	S Bootis	3
5194	*V* Bootis	6
5338	*U* Bootis	11
5504	*S* Coronae	22
5617	*U* Librae	27
5830	*R* Scorpii	11
6062	*RR* Scorpii	5
6207	*Z* Ophiuchi	29
7192	*Z* Cygni	4
7242	*S* Aquilae	9
7428	*V* Cygni	7
7456	*RR* Cygni	3
8230	*S* Aquarii	8
		April
112	*R* Androm.	12
243	*U* Cassiopeae	5
782	*R* Arietis	18
893	*U* Ceti	11
1574	*W* Tauri	5
1577	*R* Tauri	3
2625	*V* Geminorum	3
3493	*R* Leonis	11
3994	*S* Leonis	2
4511	*T* Ursae Maj.	28
5430	*T* Librae	9
5593	*W* Librae	28
5644	*Z* Librae	20
5704	*RR* Librae	27
5795	*W* Scorpii	8
5931	*S* Ophiuchi	5
6512	*T* Herculis	15
6849	*R* Aquilae	25
6905	*R* Sagittarii	10
7252	*W* Capricorni	9
7468	*T* Aquarii	8
7733	*Y* Capricorni	8
7754	*W* Cygni	20
		May
715	*S* Arietis	27
2583	L_2 Puppis	30
3184	*T* Hydrae	22
4407	*R* Corvi	15
4521	*R* Virginis	28
4596	*U* Virginis	21
4847	*S* Virginis	21
5037	*RR* Virginis	28
5174	*RS* Virginis	26
5438	*Y* Librae	15
5501	*S* Serpentis	22
5675	*V* Coronae	25
5776	*X* Scorpii	15
6044	*S* Herculis	30
6682	*X* Ophiuchi	20
7261	*R* Delphini	10
7455	*U* Capricorni	29
7560	*R* Vulpeculae	10
7907	*U* Aquarii	15:
7944	*T* Pegasi	27
8068	*S* Lacertae	6
8373	*S* Pegasi	9
8597	*V* Ceti	18
		June
1717	*V* Tauri	26
1805	*V* Orionis	29
2013	*U* Aurigae	7
2258	*V* Aurigae	30
2528	*R* Geminorum	3
2780	*T* Geminorum	22
3418	*R* Carinae	17
3825	*R* Ursae Maj.	8
4940	*W* Hydrae	20
5070	*Z* Virginis	6
5190	*R* Camelopard.	26
5831	*S* Scorpii	21
5955	*R* Draconis	2
7085	*RT* Cygni	17
7139	*RR* Sagittarii	9
8153	*R* Lacertae	9
		July
845	*R* Ceti	7
976	*T* Arietis	12
1635	*R* Reticuli	12
2478	*R* Lyncis	7
3477	*R* Leonis min.	31
3637	*S* Carinae	23
4315	*R* Comae	6
5095	*R* Centauri	25
5249	*V* Librae	1
5494	*S* Librae	9
5583	*X* Librae	25
5761	*Z* Scorpii	27
5889	*U* Herculis	27
5950	*W* Herculis	24
7118	*X* Aquilae	27:
7220	*S* Cygni	13
7299	*U* Cygni	6
7444	*T* Delphini	19
7448	*W* Aquarii	9:
8512	*R* Aquarii	30
		August
107	*T* Cassiopeae	9
466	*U* Piscium	16
1222	*R* Persei	22
1574	*W* Tauri	25
1582	*S* Tauri	4?
1855	*R* Aurigae	31
2742	*S* Geminorum	16
5511	*RS* Librae	7
6943	*T* Sagittae	20:
7045	*R* Cygni	2
7242	*S* Aquilae	3
7456	*RR* Cygni	16
7571	*V* Capricorni	2
7659	*T* Capricorni	9
7754	*W* Cygni	29
8290	*R* Pegasi	22
8600	*R* Cassiopeae	23
		September
494	*R* Sculptoris	2
4377	*T* Virginis	15
4948	*R* Canis Ven.	5
5237	*R* Bootis	24
5338	*U* Bootis	3
6132	*R* Ophiuchi	3
6512	*T* Herculis	26
7431	*S* Delphini	6
7450	*V* Aquarii	26
7560	*R* Vulpeculae	25
7577	*X* Capricorni	10
7609	*T* Cephei	12
7783	*RU* Cygni	27:
		October
114	*S* Ceti	18
782	*R* Arietis	21
906	*R* Trianguli	8
1761	*R* Orionis	19
2583	L_2 Puppis	13
2691	*T* Canis min.	29
3060	*U* Cancri	9
3170	*S* Hydrae	27
3567	*V* Leonis	11

	October	
3994	*S* Leonis	13
4492	*Y* Virginis	8
4521	*R* Virginis	20
4557	*S* Ursae Maj.	28
4816	*V* Virginis	15
5677	*R* Serpentis	15
5830	*R* Scorpii	22
6921	*S* Sagittarii	11
7468	*T* Aquarii	29
7733	*Y* Capricorni	31
8068	*S* Lacertae	7
	November	
1981	*S* Camelopard.	2:
2266	*V* Monocerotis	14
2735	*U* Canis min.	2
2857	*U* Puppis	5
2946	*R* Cancri	27
3890	*W* Leonis	13
5157	*S* Bootis	26
5194	*V* Bootis	17
5617	*U* Librae	8
5776	*X* Scorpii	30
5795	*W* Scorpii	17
5928	*T* Ophiuchi	5:
5931	*S* Ophiuchi	25
7192	*Z* Cygni	24
7234	*R* Capricorni	3
7252	*W* Capricorni	3
7458	*U* Delphini	24
7909	*S* Piscis aus.	26
	December	
434	*S* Piscium	21
806	o Ceti	9
845	*R* Ceti	21
893	*U* Ceti	3
1113	*U* Arietis	21
1717	*V* Tauri	12
2684	*S* Canis min.	11
2976	*V* Cancri	13
3637	*S* Carinae	18
4596	*U* Virginis	14
5037	*RR* Virginis	31
5430	*T* Librae	3
5831	*S* Scorpii	15
5887	*V* Ophiuchi	7
6062	*RR* Scorpii	8
6905	*R* Sagittarii	30
6923	*Z* Sagittarii	30:
7085	*RT* Cygni	24
7242	*S* Aquilae	27
7455	*U* Capricorni	18
7779	*S* Cephei	13
8230	*S* Aquarii	13

MINIMA, 1895.

	January	
782	*R* Arietis	16
1574	*W* Tauri	17
1855	*R* Aurigae	2
3186	*T* Cancri	8
3418	*R* Carinae	15
4511	*T* Ursae Maj.	10
6044	*S* Herculis	2:
6512	*T* Herculis	27
6682	*X* Ophiuchi	0:
7139	*RR* Sagittarii	20
7252	*W* Capricorni	12
7456	*RR* Cygni	22:
7468	*T* Aquarii	10
7783	*RU* Cygni	30:
	February	
2478	*R* Lyncis	14:
2528	*R* Geminorum	2
3177	*R* Leonis min.	11
3825	*R* Ursae Maj.	21
4596	*U* Virginis	22
5190	*R* Camelopard.	11
5889	*U* Herculis	10
5955	*R* Draconis	10
7220	*S* Cygni	19
7751	*W* Cygni	7
	March	
976	*T* Arietis	7
1717	*V* Tauri	29
1761	*R* Orionis	19:
2583	L_2 Puppis	31
4521	*R* Virginis	21
5494	*S* Librae	31:
5950	*W* Herculis	21
7045	*R* Cygni	5
7085	*RT* Cygni	9:
7560	*R* Vulpeculae	9
7609	*T* Cephei	3
7659	*T* Capricorni	27:
7779	*S* Cephei	31
8290	*R* Pegasi	3:
8600	*R* Cassiopeae	6
	April	
494	*R* Sculptoris	23:
845	*R* Ceti	27
2742	*S* Geminorum	10:
3637	*S* Carinae	27
	May	
114	*S* Ceti	26
466	*U* Piscium	25
1222	*R* Persei	18
1582	*S* Tauri	26?
2735	*U* Canis min.	11
5095	*R* Centauri	26:
5583	*X* Librae	6
5677	*R* Serpentis	17
7242	*S* Aquilae	23
7431	*S* Delphini	11
7450	*V* Aquarii	26
7577	*X* Capricorni	16
	June	
434	*S* Piscium	4
906	*R* Trianguli	11
1574	*W* Tauri	8
1981	*S* Camelopard.	5:
2684	*S* Canis min.	30
3994	*S* Leonis	10:
5237	*R* Bootis	15
5338	*U* Bootis	5
5795	*W* Scorpii	24:
6921	*S* Sagittarii	23:
6943	*T* Sagittae	16:
7754	*W* Cygni	17
8591	*V* Cephei	1
	July	
782	*R* Arietis	21
1944	*S* Orionis	2
2946	*R* Cancri	24
4492	*Y* Virginis	15
4557	*S* Ursae Maj.	7
5157	*S* Bootis	19
6512	*T* Herculis	10
6905	*R* Sagittarii	25:
7120	*X* Cygni	26
7192	*Z* Cygni	22:
7456	*RR* Cygni	7:
7560	*R* Vulpeculae	25
	August	
806	o Ceti	19
2213	η Geminorum	16
2539	*R* Canis min.	24
2583	L_2 Puppis	14
2625	*V* Geminorum	24
4521	*R* Virginis	13
4826	*R* Hydrae	18
5194	*V* Bootis	12
5430	*T* Librae	20
7252	*W* Capricorni	8
7468	*T* Aquarii	2
	September	
243	*U* Cassiopeae	8
432	*S* Cassiopeae	9:
513	*R* Piscium	8:
1717	*V* Tauri	14
2976	*V* Cancri	2:
3493	*R* Leonis	28
3637	*S* Carinae	24
4511	*T* Ursae Maj.	21
4596	*U* Virginis	17
7085	*RT* Cygni	15:
7428	*V* Cygni	21
	October	
715	*S* Arietis	1:
845	*R* Ceti	12
1574	*W* Tauri	28
1577	*R* Tauri	5:
2100	*U* Orionis	15:
5494	*S* Librae	9:
5583	*X* Librae	16
5955	*R* Draconis	14
6044	*S* Herculis	29:
6849	*R* Aquilae	20
7242	*S* Aquilae	16
7754	*W* Cygni	26
	November	
466	*U* Piscium	14
494	*R* Sculptoris	17:
1582	*S* Tauri	30:
1771	*R* Leporis	1
3418	*R* Carinae	22
5095	*R* Centauri	3:
5190	*R* Camelopard.	8
5338	*U* Bootis	29
5504	*S* Coronae	22
5675	*V* Coronae	27
6682	*X* Ophiuchi	26:
	December	
112	*R* Androm.	6:
1222	*R* Persei	12
2583	L_2 Puppis	29
3825	*R* Majoris	23
3994	*S* Leonis	22:
4847	*S* Virginis	24
5950	*W* Herculis	28
6512	*T* Herculis	22
6943	*T* Sagittae	10:
7139	*RR* Sagittarii	24
7456	*RR* Cygni	20:
7560	*R* Vulpeculae	9
7577	*X* Capricorni	20
7659	*T* Capricorni	21:

OBSERVATION OF COMET *b* 1894,

MADE WITH THE 12-INCH EQUATORIAL AND FILAR MICROMETER OF THE DETROIT OBSERVATORY, ANN ARBOR, MICHIGAN.

BY SIDNEY D. TOWNLEY.

[Communicated by the Director of the Observatory.]

1894 Greenwich M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
June 7 $15^h\ 56^m\ 48^s$	1	10, 6	$-0^m\ 19^s.76$	$+2'\ 19''.0$	$11^h\ 20^m\ 4^s.75$	$+40°\ 48'\ 18''.2$	9.708	0.393

Mean Place for 1894.0 of Comparison-Star.

*	α	Reduction	δ	Reduction	Authority
1	$11^h\ 20^m\ 22^s.69$	$+1^s.82$	$+40°\ 45'\ 53''.5$	$+5''.7$	W. Bessel XI, 336

OBSERVATIONS OF COMET *b* 1894,

MADE AT THE UNITED STATES NAVAL OBSERVATORY WITH THE 9.6-INCH EQUATORIAL,

BY PROF. EDGAR FRISBY.

[Communicated by the Superintendent.]

1894 Washington M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
June 2 9 19 39.8	1	20 , 4	−3 10.45	−0 38.3	11 6 47.40	+39 22 42.8	9.622	0.066
15 10 24 46.7	2	20 , 4	+0 22.63	−3 53.8	11 38 25.02	+42 14 51.4	9.754	0.343
22 10 6 19.8	3	20 , 4	−0 52.13	−5 19.0	11 52 50.54	+42 58 10.5	9.755	0.312
23 10 25 48.9	3	17 , 4	+1 7.30	−1 1.9	11 54 49.95	+43 2 27.6	9.774	0.386
28 10 17 4.0	4	15 , 3	+2 43.98	+4 35.3	12 4 28.43	+43 19 43.7	9.791	0.481
July 7 10 42 10.8	5	5 , 1	+1 13.86	+6 9.1	12 21 1.25	+43 32 46.7	9.793	0.528

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	11 9 56.12	+1.73	+39 23 15.3	+5.8	Lund Zones, 164 and 172
2	11 38 0.59	+1.80	+42 18 38.9	+5.8	Yarnall (F) 4998
3	11 53 40.85	+1.82 +1.80	+43 3 24.1	+5.4 +5.4	Bonn VI, +43°2172
4	12 1 42.71	+1.74	+43 15 3.0	+5.4	W.B. XI, 1183
5	12 19 45.67	+1.72	+43 26 33.0	+4.6	W.B. XII, 373

NEW VARIABLE OF THE *ALGOL*-TYPE.

$\alpha = 16^h\ 11^m\ 57^s.2, \qquad \delta = +13°\ 52'.0$ (1855).

Dr. KRUEGER telegraphs that Dr. HARTWIG has discovered that the star DM. +13°3115 is a variable of the *Algol*-type. Epoch, 1894 Sept. 10.35 Greenwich M.T.; period, 2.00 days.

NEW SHORT-PERIOD VARIABLE,

BY A. W. ROBERTS.

Lacaille 5954; $14^h\ 23^m\ 36^s$, $-56°\ 19'\ 52''$ (1875).

This star is a variable of short period. It is XIV, 1502, in the Cordoba Zone Catalogue, the magnitudes there recorded being 7 and 7½. In STONE's Catalogue the magnitude is 6¾.

It has been watched regularly for nearly two months, and the following results are obtained from a reduction of the observations.

Amplitude of variation,	$6^M.7$ to $7^M.6$
Ascending period,	2 days, 12 hours
Total period,	5 days, 13 hours
Epoch of maximum,	1894 July 27.03

Loredale, Alice, South Africa, 1894 *August* 6.

CORRIGENDA.

No. 325, p. 98, line 10, *for* 0″.5 *put* 0′.5.
p. 103, col. 2, line 25, *for* nearly *put* really.
p. 104, col. 1, line 13, *for* notations *put* rotations.

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VARIATION OF (3416) —VELORUM AND (5949) —ARAE, BY PROF. A. W. ROBERTS.
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EPHEMERIDES OF LONG-PERIOD VARIABLES FOR 1895, BY DR. S. C. CHANDLER.
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OBSERVED MAXIMA OF LONG-PERIOD VARIABLES, WITH NOTE ON A SUSPECTED NEW VARIABLE.

By P. S. YENDELL.

243. *U Cassiopeae.*

I have six observations of *U Cassiopeae*, from 1894 June 13 to Aug. 22. A maximum of about $9^{M}.0$ is somewhat uncertainly indicated on July 14. When last looked for, on August 22, it was not seen, and must have been below 10^{M}

1981. *S Camelopardalis.*

I observed this star five times after the observations published in *A.J.* 315, the date of the last observation being April 25, when its light was by estimation $9^{M}.1$. These five observations indicate a distinct secondary maximum of $8^{M}.4$, about April 11.

I desire here to call the attention of observers to a star in the immediate neighborhood of 1981, of whose variability my observations give strong indication.

Its approximate place for 1855 is

$$\alpha = 5^{h}\,27^{m}\,22^{s}, \quad \delta = +68°\,36'.1,$$

being about 1^{m} preceding a line joining DM. 68°402 and 68°403, at nearly half the distance from the first to the second.

I first observed the star on 1892 May 27, when it was used as a comparison-star for 1981; the magnitude indicated by this observation is $8^{M}.8$. The fact that it was not in the DM. catalogue, nor on the chart, at once aroused suspicion of the star's variability. In the press of other work, however, it was neglected, and no further observation was made until 1892 Nov. 16 and 20, when it was again used as a comparison-star for the same star when near its minimum; the magnitudes indicated are respectively $10^{M}.1$ and $10^{M}.3$. The discrepancy between these two values again attracted attention to the star, and it has since been watched as continuously as circumstances permit. I have in all sixty observations; these indicate a maximum of $9^{M}.6$ on 1893 Aug. 9–10, and minima of $10^{M}.4$ on 1893 Jan. 2 and Nov. 2; my last three observations, 1894 Mar. 1, 4 and 6, give a mean magnitude of $9^{M}.75$. It seems probable that the next maximum will occur in March, 1895.

Although the change indicated is slow, and the range limited, my impression of the reality of the variation is very strong; and I am very desirous that the star should be examined by some observer equipped with a telescope of greater capacity than my own, in which it is at all times a difficult object to observe, and when near its minimum, a very difficult one.

The star is too faint in my telescope for any color to be distinguishable.

7118. *X Aquilae.*

Since publishing my confirmation of this star's variability, in *A.J.* 323, I have kept it under observation as continuously as possible. A maximum of $8^{M}.2$ was passed on July 30, and is sharply indicated by my observations; there is some indication of a secondary maximum of $8^{M}.4$, about August 10. On Aug. 26, when last observed, the star was estimated at $9^{M}.4$.

8324. *V Cassiopeae.*

I have nine observations of this star, from 1894 June 7 to Aug. 22. A maximum of $7^{M}.1$ is very sharply indicated on July 10. The estimated magnitude at the first observation was about $9^{M}.1$, and at the last, $9^{M}.0$.

The spring and summer of 1894 have been very unfavorable for observations of variable stars, which accounts for the apparent meagreness of the results above recorded. Of course a large number of other observations have been secured in this interval, but a publication of them must be deferred for the present, for the above reason.

Dorchester, Mass., 1894 *September* 1.

THE GREAT METEOR OF JULY 27, 1894,

BY E. E. BARNARD.

On the evening of July 27, while reducing observations in my office, I was suddenly startled by two dull reports like distant cannon or thunder, or perhaps more properly like the discharge of two blasts in a distant quarry. So unusual was the sound in the quiet of the mountains that I hastened on to the roof of the observatory to find the cause of it. Looking to the east I at once saw a bluish white puff of smoke hanging in the eastern sky. It was then evident that a large meteor had exploded to the east of us.

Noting the time by my watch and estimating the interval since the reports, I made the time of explosion $7^h\ 35^m\ 13^s \pm 15^s$, Standard Pacific Time. As four other observers made it one minute later, I must have read the minute-hand one minute wrong. I therefore adopt for the time of the hearing of the explosions by me, $7^h\ 36^m\ 13^s \pm 15^s$, Standard Pacific Time.

As this smoke seemed to be persistent, I hurried to the 12-inch and took a series of pointings on the densest mass — a roundish cloud about 1° in diameter, and forming the north-east extremity of the triangular strip the smoke had formed itself into. This mass remained visible some time after the other portions faded out, and did not materially change its form.

Following are the pointings on the object — at first it was easily seen in the finder, but towards the last could be seen only with the naked eye.

Sid. time. h m	α h m	δ °	
15 57	20 16.9	+11.8	in finder.
16 0	20 15.9	12.3	in finder.
16 3	20 13.9	12.9	in finder.
16 7	20 10.5	13.3	pointing along tube.
16 10.5	20 5.4	14.0	pointing along tube.
16 14.5	20 1.4	+15.2	pointing along tube.

Ceased to be visible after this.

The positions were corrected by pointings on a star.

The meteor itself was seen (among others) by Mr. POOLE, a student at the observatory, who noted the time of appearance, which was at $7^h\ 29^m\ 45^s$ Standard Pacific Time. This would give about 6½ minutes for the sound to reach us and would place the meteor some 80 miles distant. The explosion evidently occurred over the San Joaquin Valley, in the direction of the Yosemite.

From several who saw the meteor in its descent, it consisted of a ball of fire, about as big apparently as the full moon, which fell vertically downwards.

There were two distinct reports, the second being about one-half as intense as the other, and following it by about one second.

Mt. Hamilton, 1894 *July* 29.

MEAN EPOCHS OF OBSERVATIONS OF THE *DLX* STARS OF THE ÅBO CATALOGUE OF ARGELANDER,

BY HERMAN S. DAVIS.

While computing definitive declinations and proper motions of the fifty-six stars used in the Columbia College investigation of latitude-variation, there was required the epoch of observation of several well observed stars in the Åbo Catalogue. While looking for the separate observations in the five volumes of original data, it occurred to me that it might be of service to deduce the mean epoch of all the stars at the same time, since these volumes are so scarce; and moreover, I found that 1830.0, the usually assumed epoch, was in some cases in error by nearly three years.

Opportunity was given me by Prof. REES of Columbia College to consult these volumes kindly placed at my disposal by Prof. PICKERING at Harvard Observatory, and I consequently give below a table showing the epoch of each star as numbered in the Åbo Catalogue.

Except in a very few cases, these epochs were computed by expressing each date in the fractional part of a year to two decimal places, and the mean taken to three places, though the third figure is omitted in printing. Where there are two dates opposite a star-number, the first is the mean for observations in right-ascension, and the second for those in declination. Where the number of observations found differs from the number called for in the Catalogue, I have found the mean of all the dates except those which most obviously, by reason of weak determinations, must have been omitted in deducing the catalogue positions. In every such case, however, I have given the actual number of observations used by me, expressing them in small figures as exponents and subscripts, the former always applying to right-ascension, and the latter to declination.

In the course of this work numerous typographical errors were found in addition to those already published at the end of each volume. I give a table of the most important of these at the end of the table of epochs.

In addition to his time and instrumental-constant stars, I find about forty stars which have been apparently well observed in both coordinates, but which remain unreduced. For some future paper I may prepare a catalogue of these.

No.	Epoch 1800+	No.	1800+	No.	1800+	No.	1800+	No.	1800+	No.	1800+	No.	1800+	No.	1800+
1	28.29 28.30	41	30.90	81	29.58	121	29.0^{82}_{80}	161	31.11^{6}_{6}	201	28.16	241	29.13	281	28.80
2	29.17	42	29.08^{13}_{13}	82	28.31 28.30	122	29.09	162	28.15	202	28.97	242	29.24	282	28.31
3	29.2^{130}_{130}	43	28.39	83	28.95	123	29.2^{137} 29.3_{119}	163	27.95	203	28.29	243	29.07	283	29.28
4	28.85	44	29.78	84	28.29	124	28.90	164	31.13^{6}_{6}	204	28.14 27.86	244	28.40	284	30.36
5	29.62	45	29.84	85	28.79	125	28.24	165	28.21	205	31.18 ?	245	29.12	285	28.86
6	29.77	46	29.04	86	29.86	126	29.48	166	28.15	206	27.92	246	29.23	286	29.29
7	28.68	47	29.67	87	28.91	127	29.17	167	29.17	207	28.29	247	29.30	287	29.37
8	27.98 27.95	48	29.48	88	30.09	128	28.38	168	29.25	208	27.81	248	27.59	288	29.43
9	30.94	49	29.81	89	28.4^{96}_{95}	129	31.09	169	28.23	209	28.64	249	28.76	289	29.83
10	28.85	50	31.07^{4}_{4}	90	28.78	130	29.89	170	31.08	210	31.31	250	30.05	290	29.37
11	31.25	51	28.88	91	29.43	131	30.12	171	28.15	211	27.35	251	28.47	291	29.28
12	30.91	52	30.28	92	30.87	132	28.17	172	29.16	212	28.21	252	29.54	292	31.26
13	30.26	53	29.56	93	28.94	133	29.17	173	28.60	213	28.23	253	29.18	293	29.93^{11}_{11}
14	29.33^{12}_{12}	54	30.89	94	28.76	134	30.59	174	29.26	214	27.71	254	29.61	294	30.36
15	28.12	55	29.19	95	28.46	135	30.11	175	29.66	215	29.1^{159} 29.0_{134}	255	28.97	295	29.27
16	28.83	56	29.96	96	29.61	136	29.25	176	28.26	216	28.29	256	29.21	296	29.35
17	30.47 30.41	57	28.70 28.71	97	31.02	137	29.1^{136}_{101}	177	29.20	217	29.05	257	29.30	297	29.52
18	31.02	58	28.86	98	29.93	138	28.15	178	28.59	218	28.22^{65}_{65}	258	29.02	298	29.51
19	27.63	59	28.62 28.63	99	29.62	139	31.03	179	28.80 28.76	219	29.22	259	28.32	299	29.30
20	28.86	60	31.21^{9}_{9}	100	30.64	140	30.08	180	29.31	220	28.53	260	29.23	300	29.37
21	29.94	61	29.8^{138} 29.5_{64}	101	29.49 29.40	141	28.85	181	31.14	221	28.21	261	28.62	301	29.90
22	30.39	62	29.17	102	28.46	142	27.36	182	28.27	222	27.64	262	29.26	302	28.8^{139}_{108}
23	29.03	63	28.84	103	29.26	143	28.12	183	27.89	223	31.30	263	30.35	303	30.34
24	29.89^{7}_{7}	64	29.99	104	30.08	144	28.65	184	28.26	224	28.53	264	29.3^{34} 29.1_{69}	304	28.71
25	31.05	65	28.70	105	31.02	145	29.17^{12}_{12}	185	31.19	225	30.29	265	29.2^{79}_{71}	305	29.33
26	30.07	66	29.99	106	29.13	146	29.12	186	28.45	226	28.56^{40}_{40}	266	28.29	306	28.52
27	31.10^{1}_{1}	67	28.85	107	29.96	147	28.60	187	29.26	227	31.30	267	28.31	307	29.38
28	28.17	68	29.14	108	29.2^{158}_{132}	148	28.8^{111} 28.7_{99}	188	28.07	228	29.62	268	31.30	308	28.91
29	30.30^{8}_{8}	69	28.37	109	29.49	149	29.66	189	29.21	229	28.48	269	27.28	309	28.00^{9}_{9}
30	29.26	70	29.89	110	29.38	150	28.33	190	28.26	230	28.25	270	28.30	310	31.24
31	28.84	71	30.02	111	30.10	151	28.56	191	28.16	231	29.26^{6}_{6}	271	28.30	311	29.31
32	30.00	72	28.55	112	27.35	152	27.96	192	28.55^{49}_{49}	232	28.52	272	27.31	312	28.7^{84}_{83}
33	30.68	73	30.88	113	28.77	153	28.45	193	28.73	233	27.8^{7} 27.9_{6}	273	28.29	313	29.42
34	30.96	74	30.04	114	30.06	154	28.67	194	31.30	234	28.25	274	28.38	314	27.80
35	29.27	75	28.89	115	31.05	155	27.26	195	29.0^{127}_{96}	235	28.81^{9}_{9}	275	28.55	315	28.40
36	28.30	76	30.99	116	28.42	156	29.1^{169}_{168}	196	31.24	236	29.26	276	29.36	316	31.30
37	30.01	77	28.25 28.30	117	29.15	157	30.17	197	28.02	237	28.26	277	28.29	317	29.06
38	29.26	78	28.86	118	28.64	158	29.2^{210} 29.3_{175}	198	28.13	238	29.09	278	30.66	318	28.79
39	29.06 28.84	79	29.73	119	28.88	159	29.20	199	31.30	239	28.98	279	28.31	319	29.13
40	29.88	80	29.2^{76}_{73}	120	29.1^{266} 29.0_{165}	160	29.3^{196}_{185}	200	31.01*	240	27.94	280	28.87	320	29.40

* 10 *Leonis*, Bradley 1349 ; See Errata.

No.	1800+	No.	1800+	No.	1800+	No.	1800+	No.	1800+	No.	1800+	No.	1800+	No.	1800+
321	29.0^{168}_{117}	351	29.39	381	28.54	411	29.25	441	28.08	471	27.67	501	29.29	531	29.68
322	29.75	352	28.42	382	29.37	412	28.15	442	29.96	472	28.62	502	28.65	532	28.71
323	28.14	353	28.10	383	27.63	413	28.26	443	29.45	473	28.70	503	28.64	533	30.77
324	29.14	354	28.44^{80}_{80}	384	29.50	414	28.65	444	28.73^{82}_{82}	474	28.98^{311}_{282}	504	30.38	534	29.65^{22}_{22}
325	28.53	355	27.89	385	28.44	415	28.78	445	28.59	475	28.62	505	29.0^{117} 28.5_{78}	535	29.2^{115} 29.0_{89}
326	28.37	356	29.2^{162} 29.4_{96}	386	29.08 29.04	416	28.13	446	27.72	476	29.28	506	29.12	536	29.89
327	27.65	357	28.42	387	30.63	417	28.58	447	27.49	477	28.76	507	28.65	537	30.58
328	28.45	358	28.50	388	27.64	418	28.59	448	28.44^{23}_{23}	478	28.44	508	29.66	538	28.77
329	28.41	359	28.41	389	27.49	419	28.80	449	28.59	479	28.65	509	27.70	539	29.57
330	29.38	360	29.27	390	29.48	420	28.2^{120}_{120}	450	29.0^{164} 28.9_{141}	480	31.18	510	30.49	540	29.88^{7}_{7}
331	29.30	361	29.0^{117} 28.9_{99}	391	29.72	421	28.26	451	28.66	481	$28.{}^{65}_{37}$	511	29.77	541	28.55
332	29.70	362	28.94	392	27.50	422	28.17	452	29.0^{184} 28.9_{158}	482	$28.{}^{65}_{41}$	512	27.75	542	29.30
333	31.14	363	30.38	393	28.72	423	28.53	453	28.74	483	28.72	513	28.65	543	30.33
334	29.37	364	27.39	394	28.34 28.35	424	28.48	454	28.81	484	29.87	514	28.96	544	30.00
335	28.39	365	30.37	395	28.79	425	28.92 28.90	455	29.0^{136}_{121}	485	30.65	515	28.62 28.77	545	28.77
336	31.31	366	27.93	396	29.07	426	28.62	456	28.61	486	27.60	516	28.62 28.47	546	27.73
337	28.92	367	28.74	397	28.71	427	29.57	457	28.65	487	28.67	517	29.83	547	28.71
338	28.71 28.74	368	29.42	398	28.75	428	28.55^{17}_{17}	458	29.01	488	27.60 27.59	518	28.68	548	28.39
339	29.12	369	28.97	399	28.48	429	27.74	459	27.61	489	28.27	519	28.57 28.56	549	27.76
340	28.71	370	28.41	400	29.48	430	28.63	460	28.21	490	29.54	520	28.69	550	28.07
341	31.32	371	29.34	401	28.91	431	28.7^{160}_{136}	461	28.78	491	28.34^{96}_{96}	521	30.13	551	28.81
342	27.43	372	30.37^{5}_{5}	402	29.2^{76} 29.1_{69}	432	28.65	462	28.88	492	28.65	522	30.17 30.08	552	30.15
343	28.63	373	28.70	403	29.49	433	28.79	463	29.0^{42}_{33}	493	28.77	523	28.04	553	28.71
344	29.65	374	28.98 28.97	404	28.48	434	28.71	464	28.6^{33}_{33}	494	27.61	524	29.75	554	28.80 28.81
345	29.44	375	27.97	405	28.76	435	28.40	465	30.65	495	28.43	525	30.70	555	29.88
346	27.43	376	28.90	406	28.40	436	28.73	466	28.79	496	27.60^{7}_{7}	526	28.76	556	29.64
347	29.14	377	29.47	407	30.40	437	28.22	467	28.48	497	30.46	527	29.41	557	29.32
348	28.89	378	28.85	408	28.07 28.04	438	28.79	468	28.59	498	27.69	528	30.60	558	27.83
349	29.48	379	29.47	409	29.3^{81}_{68}	439	27.85	469	30.13	499	28.94	529	28.49 28.47	559	30.94
350	29.67	380	29.27	410	29.10	440	28.20	470	27.58	500	28.82	530	28.20	560	29.4^{158} 29.3_{120}

Errata to the Volumes of Observations.

For 1827,

Page 59	For	*β Cephei*	read	*α Cephei*
60	"	April 29	"	April 19
63 April 27	"	*η Urs. min.*	"	*α Urs. min.*
69	"	*α Can. min.* 7h 3m	"	7h 30m
90	"	*θ Urs. Maj.* s.p.	"	*o Urs. Maj.* s.p.
127	"	*α Bootis* 13h 7m	"	14h 7m
Oct. 28 Dec. 17	"	61 *Ceti*	"	66 *Ceti*

For 1828,

Page 19	For	*η Urs. min.*	read	*ζ Urs. min.*
35	"	*α Can. min.*	"	*α Can. Maj.*
	"	*π Leonis min.*	"	11 *Leonis min.*
51	"	April 7	"	April 17
57	"	*σ Urs. min.*	"	2 *σ Urs. min.*
58	"	*o Urs. min.* s.p.	"	*α Urs. min.* s.p.
135 Oct. 12	"	*σ Draconis*	"	*δ Draconis*

For 1829,

Page 11	For	*α Draconis*	read	*δ Draconis*
24	"	*ι Virginis*	"	*i Virginis*
71	"	*α Urs. min*, s.p.	"	*β Urs. min.* s.p.
May 17	"	*τ Serpentis*	"	*γ Serpentis*
May 25	"	Anon $12^h\ 48^m$	"	Anon seq. 12^h etc.

For 1830,

Page 34 April 10	For	*α Urs. min.* s.p. 18^h	read	12^h
39	"	*n Virginis*	"	*η Virginis*

For 1831,

Page 91 Jan. 9	For	Anon $4^h 25^m 21^s.37$	read	$4^h\ 45^m$ etc.
99 Jan. 24	"	Anon $4^h 45^m$		the 'indicum' should be 127° etc.

Åbo 200 1 *Sextantis* $9^h\ 28^m$ wherever found in volumes for 1830 or 1831, should be 10 *Leonis*, Bradley 1349.

Åbo is recorded in the observations as Pi. I, 142.

Columbia College, New York City, 1894 *June* 26.

ON A NEW VARIABLE OF THE *ALGOL*-TYPE, 6442 *Z HERCULIS*,

DM. $+15°3311$; (1855) $17^h\ 51^m\ 34^s$, $+15°\ 9'.3$.

BY S. C. CHANDLER.

Observations, beginning 1894 July 22, have established the fact that this star is a variable of the *Algol*-type. Until July 28 it was always seen as $7^M.2$ or $7^M.3$; but on that date it was found a half-magnitude fainter. On Aug. 5, a watch of three hours gave a continuous rise from $7^M.63$ to $7^M.32$. This phenomenon was repeated on Aug. 9, Aug. 17 and Aug. 21; the brightness on intervening dates being always normal.

I was led to make these observations by the note of Prof. **Müller** and Dr. **Kempf**, on p. 482 of their catalogue (against Nos. 2404 and 2405), which called attention to the discordance of their measures and remarked that these stars deserve watching.

A combination of all the data gave the elements of minimum,

$$1894\ \text{Aug.}\ 5^d\ 12^h\ 14^m\ \text{Gr. M.T.}\quad +3^d\ 23^h\ 50^m.0\ E$$

The period is probably correct to within a fraction of a minute; but the epoch is a little uncertain, being found from partial phases. The observations do not suggest further subdivision of the period, although this is possible. The range of variation is from $7^M.3$ to $7^M.9$.

Mr. **Yendell** shortly after confirmed the variation and its character, and the above definitive notation has therefore been assigned. After the above five partial minima had been obtained, as they were advancing into the twilight in this longitude, the above elements, with an ephemeris, were sent (Aug. 26 and 29) to Potsdam and Upsala, in the hope that observations might be continued there.

ON THE VARIABILITY OF DM. +15°3311,

BY PAUL S. YENDELL.

My attention was called to the variability of this star, and the probability of its being of the *Algol*-type, by **Chandler**, in a letter dated 1894 August 5. I at once began as close a watch upon it as the weather permitted. On August 17 and 21, and Sept. 6, I found the star below its normal light, and though, on account of twilight, no actual minimum was observed, sufficient evidence was secured to fully confirm both the fact and type of the star's variability.

Note. — Mr. **Ritchie** writes: "By my mistranslation of Dr. **Krueger**'s cable dispatch, on p. 120 of *A.J.*, 327, the variable of the *Algol*-type whose discovery was telegraphed to Kiel by **Hartwig** on Sept. 15, was given as DM. +13°3115, instead of +15°3311." It thus appears that the star is identical with the one discovered by **Chandler** in the beginning of August, confirmed by **Yendell**, and given the name of *Z Herculis*, according to the preceding two articles by those gentlemen. — **Ed.**

GRAPHICAL SOLUTIONS OF THE ORBIT OF *SIRIUS*,

BY ALEX. WM. ROBERTS.

In the June number of *Astronomy and Astro-Physics* there is a very valuable paper by Mr. **Howard** on the orbit of *Sirius*. The method adopted by Mr. **Howard** is an extremely elegant one, and the conclusions drawn from certain irregularities which seem to affect the motion of *Sirius* and his companion, or perhaps both, are of no common interest. It is not my purpose, however, to deal with these anomalies; the object of the present paper is to offer a mild protest against the "special pleading" for the superiority of a graphical method of computing binary-star orbits over any other, that begins and ends Mr. **Howard**'s paper. There is no doubt that much may be said in favor of this method; it is simple; it is short; it tells plainly and visibly its tale of correspondence or the reverse. In the hands also of such experienced computers as SEE and BURNHAM it has proved a method of no mean value.

Yet after all has been said in its favor that can be said, the fact remains that is only *a* method. The rigorous method of determining the most probable form of any curve from a given set of observations is the purely analytical one. It may be objected that in double-star work the measures are usually so inexact that it is useless introducing refined methods of reduction. To that it may be replied, that if the observations were made with a cart-wheel, a rigorous investigation of (1), the errors of the wheel and (2), the actual measures made, would yield the best results. If the observations are bad, then the analytical method will give as good results as any other; if the observations are absolutely correct, then only one method can be adopted in producing them.

Mr. HOWARD instances as an example of the superiority of the graphical method of computation, a solution of the orbit of *Sirius*. However, he incidentally remarks that he has "tried more than twenty different ellipses without obtaining one that was thoroughly satisfactory, having to contend in every case with two persistent characteristic discrepancies, and whenever any one of them was reduced the other immediately became prominent."

Apart altogether from the discrepancies which have troubled Mr. HOWARD, twenty different ellipses could easily be drawn, each of which would satisfy the mean places plotted down, for a rigorous solution of the problem leads to practically an indeterminate result.

Thus if any one of the orbits recently computed be taken, and partial differential coefficients computed for the different elements, it will be found on reducing, according to the usual methods, that there is no determinate solution, the problem being an indeterminate one. The meaning of such a result is that within certain limits we may have twenty, or for that matter two hundred orbits, each of which will satisfy the observations fairly well. Such a conclusion is obviously without the range of a graphical solution.

Two years ago I spent the spare moments of months over the orbit of *Sirius*. Mean places were obtained by weighting the several observations according to the dividing power of the telescope, the number of observations, and the distance of the two stars. Each mean place gave an equation of the type

$$\alpha x + \beta y + \gamma x^2 + \delta xy + \varepsilon y^2 + 1 = 0$$

where $x = \delta \cos \varphi$; and $y = \delta \sin \varphi$.

A least-squares solution gave the values of α, β, γ, δ, ε; but the weights of these quantities were so small and their probable errors so great that it was evident the smallest change in any of the mean places would seriously affect the values obtained.

On transposing the elements α, β, γ, δ, ε, of the apparent ellipse, into the orbital elements I found

$$\begin{aligned} T &= 1893.598 \\ P &= 51.10 \\ \varepsilon &= 0.6068 \\ \lambda &= 46^\circ\ 26' \\ \iota &= 47\ \ 22 \\ \Omega &= 35\ \ 45 \\ a &= 8''.35 \end{aligned}$$

Forming partial differential coefficients for ΔT, ΔP, $\Delta\varepsilon$, $\Delta\lambda$, $\Delta\iota$, $\Delta\Omega$, Δa, I found for position-angles, that the coefficients for ΔP and $\Delta\lambda$ were almost exactly in the ratio of 1 : 1.46, and that a similar relation existed between the coefficients of ΔT, $\Delta\varepsilon$ and $\Delta\lambda$.

Any corrections to the orbit were therefore out of the question, as six of the quantities to be determined could only be represented as functions of the seventh. And this result does not depend upon our grouping of the observations, or upon the selection or determination of mean places; it is inherent in the nature of the problem and cannot be overcome until more observations give new data for determining the value of the one unknown correction.

As we have said, six of the corrections to the elements can only be determined as a function of the seventh, and the amplitude of the values of the different corrections will of course depend upon the values we give to the unknown.

These values, further, must lie within certain limits; so it is possible to determine rigorously the probable limits of error which may affect the elements, supposing the mean places to be well determined.

Thus the period of *Sirius* may be in error three and one-half years either way, and the longitude of the periastron 50′. The other elements may similarly be treated, but into their limits of error it is unnecessary to inquire.

To return therefore to the point from which we started, a graphical solution of the orbit of *Sirius* can have no greater claims to acceptance than any other; while as a method of rigorous, searching investigation, it must always be inadequate.

As auxiliaries to more thorough, more comprehensive, investigations graphical solutions have their place, and their importance as such cannot be over-estimated; but to begin and end with them seems to me to fall short of excellence.

With regard to the discrepancies which appear in the comparisons between observed and computed places, it would be well to investigate most carefully the influence of personality on these anomalies.

It may be said, however, that the residuals obtained from the orbit given in this paper yield the same persistent negative values as appear in Fig. 8 (p. 431) of Mr. HOWARD's paper.

ON THE VARIABLE STAR 6573 *Y SAGITTARII*,

By EDWIN F. SAWYER.

Since my announced discovery of the variability of this star, and the publication of provisional elements in *A.J.* 145 and 148, no further results of mine up to the present time have been published.

I have recently, however, in connection with other long neglected work of the same nature, reduced anew all of my 171 observations, extending from 1886 Sept. 22 to 1893 Oct. 11, and including the years 1886–90 and 1893.

I have also inserted an isolated observation made in a sequence 1882 Sept. 5, in connection with my revision of the *Uranometria Argentina*. All the observations have been used in the formation of a mean light-curve, using the period $5^d.7732$ given by Dr. Chandler in his Second Catalogue. A comparison of my results, given below, with Dr. Chandler's elements, fails to show any appreciable correction.

Observed Maxima.

E	Boston M.T.	Wt.	O—C d
1	1886 Sept. 30.639	3	+0.056
2	Oct. 6.334	2	— .022
4	17.757	1	— .145
5	23.785	3	+ .109
7	Nov. 3.810	2	— .412
8	9.830	1	— .165
9	15.590	1	— .178
10	22.050	1	+ .508
46	1887 June 17.083	1	— .294
48	28.906	2	— .017
55	Aug. 8.521	1	+ .185
56	14.037	2	— .072
58	25.540	1	— .115
62	Sept. 17.792	3	+ .044
65	Oct. 5.311	1	+ .243
67	16.795	1	+ .181
69	28.675	1	+ .515
70	Nov. 2.790	1	— .144
71	8.070	1	— .637
108	1888 June 9.458	1	+ .143
112	July 2.921	1	+ .513
113	8.839	1	+ .658
114	13.701	1	— .253
117	31.629	2	+ .355
119	Aug. 12.512	2	+ .692
122	29.245	2	+ .105
123	Sept. 4.575	1	+ .662
127	26.629	3	— .377
128	Oct. 2.966	1	+ .187
129	8.642	1	+ .090
132	25.766	1	— .106
133	31.470	1	— .175
173	1889 June 19.663	1	+ .090
175	July 1.396	1	+ .276
176	6.396	1	— .497
178	18.750	1	+ .311
179	24.575	1	+ .363
184	Aug. 22.338	1	+ .260
185	27.945	2	+ .093
188	Sept. 15.035	1	+ .864
189	19.800	1	— .144
250	1890 Sept. 7.311	1	+ .201
429	1893 July 6.717	2	+ .205
431	18.092	1	+ .033
434	Aug. 4.408	1	+ .030
436	16.021	2	+0.096
439	1893 Sept. 2.085	1	—0.159
440	7.807	2	— .211
441	13.819	1	+ .028
444	30.956	1	— .154
445	Oct. 6.506	1	—0.378

Observed Minima.

E	Boston M.T.	Wt.	O—C d
—256	1882 Sept. 7.090	1	+1.159
0	1886 Sept. 22.973	2	+0.103
+ 1	28.555	1	— .088
2	Oct. 4.886	1	+ .470
3	10.820	1	+ .631
4	15.793	1	— .169
5	21.829	3	+ .093
7	Nov. 3.119	2	+ .837
8	7.917	2	— .138
9	13.806	1	— .022
10	19.587	2	— .015
11	24.928	1	— .417
46	1887 June 15.942	2	+ .505
48	27.317	2	+ .334
50	July 8.839	2	+ .309
51	13.687	2	— .616
52	20.194	2	+ .118
53	26.021	1	+ .172
55	Aug. 6.199	1	— .197
56	12.003	1	— .166
57	18.236	2	+ .294
60	Sept. 3.973	2	— .289
61	10.081	3	+ .046
62	15.527	3	— .281
63	21.867	1	+ .286
67	Oct. 15.109	2	+ .435
68	21.020	1	+ .573
70	Nov. 1.250	1	+ .256
71	6.400	1	— .367
72	12.250	1	— .290
107	1888 June 1.430	1	— .172
109	13.078	3	— .070
113	July 6.368	1	+ .127
114	12.917	1	+ .903
117	29.278	1	— .056
118	Aug. 4.375	1	+ .268
119	9.941	1	+ .061
122	27.121	3	—0.079

E	Boston M.T.	Wt.	O—C
			d
123	1888 Sept. 2.344	1	+0.371
127	24.856	1	— .210
128	30.110	2	— .729
132	Oct. 24.270	1	+ .338
133	30.250	1	+ .545
134	Nov. 4.926	2	+ .448
174	1889 June 23.340	2	— .066
178	July 16.348	2	— .151
180	27.333	1	— .713
183	Aug. 13.908	1	— .456
185	25.333	1	— .579
190	Sept. 23.333	1	— .445
193	Oct. 10.835	1	—0.262
430	1893 July 10.240	2	—0.106
431	15.914	2	— .205
432	21.659	2	— .233
434	Aug. 2.620	2	+ .182
435	8.508	2	+ .296
436	14.256	2	+ .271
439	30.366	2	— .938
440	Sept. 5.530	2	— .548
441	11.793	3	— .058
442	17.261	1	— .363
444	28.670	1	— .500
445	Oct. 4.695	1	— .249
446	11.002	3	+0.285

The comparison-stars and the light-scale are:

α 1875.0	δ 1875.0	U.A.	SAWYER	Light Scale
h m s	° ′	M	M	
18 17 54	—20 36.3	5.1	5.3	22.2
18 7 46	—20 45.8	5.8	5.7	16.7
18 6 45	—21 44.7	6.0	6.15	13.2
18 22 51	—18 48.3	6.0	6.2	10.0
18 8 10	—18 41.9	6.5	6.3	6.9
18 20 39	—17 52.5	6.6	6.55	4.5
18 9 54	—17 24.9	6.4	6.6	2.2

The characteristics of the fluctuations are a very rapid and uniform increase, and a uniform and much slower decrease. The average variation during increase is about $0^{M}.45$ a day, while the average daily decrease is $0^{M}.22$. The readings of the light-curve give the following

LIGHT-TABLE.

Time from Max.			Time from Max.		
d	Steps	M	d	Steps	M
—1.95	2.20	6.60	+1.25	11.72	6.17
—1.75	2.38	6.59	+1.50	10.70	6.19
—1.50	2.95	6.58	+1.75	9.60	6.21
—1.25	3.90	6.56	+2.00	8.40	6.25
—1.00	5.18	6.48	+2.25	7.15	6.30
—0.75	8.00	6.26	+2.50	6.10	6.38
—0.50	13.32	6.10	+2.75	4.94	6.51
—0.25	15.40	5.90	+3.00	3.90	6.56
0.00	15.60	5.75	+3.25	3.00	6.57
+0.25	15.35	5.91	+3.50	2.41	6.59
+0.50	14.50	5.97	+3.75	2.20	6.60
+0.75	13.51	6.10	+4.00	2.30	6.59
+1.00	12.70	6.14			

Range of variation, $5^{M}.75$ to $6^{M}.60$. Duration of increase, 1.94 days; of decrease, 3.83 days.

NEW ASTRONOMICAL WORK.

Spectroscopic Observations of Nebulae made with the 36-inch Refractor of the Lick Observatory by J. E. KEELER.

This important memoir forms Part IV (pp. 161–229) of Vol. III, of the *Publications of the Lick Observatory* (1894), and includes observations made in 1890 and 1891, chiefly for the purpose of determining the wave-lengths of the principal lines in the nebular spectrum and thus measuring the velocity of the nebulas in the line of sight.

After an account of the previous observations of nebular spectra, a description of the visual star-spectroscope is given, with an explanation of the experiments made in testing the instrumental errors, and of the method of observation adopted. The fourth (or third) order spectrum of a Rowland grating of 14438 lines to the inch was employed, and the observations were differential. The measures are not all printed in detail, but a representative series of examples is selected. In seven sets of observations of *Venus* at different times, the greatest difference between the observed and the computed velocity of the planet in the sight-line is 2.3 km., an excellent test of the accuracy of the adjustments and of the skill of the observer.

The separate results of the observations of twenty-six nebulas are given, and the velocities of fourteen of these could be determined. Until the velocity of the nebula in *Orion* was successfully measured by the displacement of the third line (Hydrogen β), the normal wave-lengths of the first and second nebular lines — their wave-lengths when observer and nebula are relatively at rest — had been indeterminate, as these lines have no analogues in any terrestrial substances yet investigated, and as they are not represented by dark lines in any maps of the solar spectrum. The results of thirteen sets of measures gave, as the velocity (recession) of the nebula, $+17.7 \pm 1.3$ km. per second, and the normal wave-lengths of the first and second nebular lines become λ 5007.05 ±0.03 and λ 4959.02 ±0.04 on Rowland's scale.

The average velocity of the fourteen nebulas is 26.9 km., a quantity somewhat larger than the average velocity of fifty-one stars measured by VOGEL and SCHEINER, 16.5 km. per second.

The memoir concludes with sections on the character and origin of the nebular lines, and the constitution of nebulas.

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NEW ASTRONOMICAL WORK.

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ASTRONOMICAL JOURNAL.

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FURTHER PROOF OF ECCENTRICITY IN THE ANNUAL COMPONENT OF THE POLAR MOTION,

By S. C. CHANDLER.

1. In *A.J.* 323 it was shown that the observations of 1891–92 strongly indicate that the annual component of the polar motion is not a circle, but a very eccentric ellipse, inclined about 53° to the Greenwich meridian, with major and minor axes of $0''.32$ and $0''.10$, respectively. Shortly afterwards I found that the 1890 and 1893 observations corroborated this conclusion, giving almost precisely the same dimensions and position of this ellipse. Its definitive elements, derived from all the observations, are: —

a = major axis,	$0''.30$
b = minor axis,	0.08
ω = inclination of major axis to Greenwich meridian,	45°
L = sun's longitude when pole is at end of major axis,	15° and 195°
T = corresponding dates,	Apr. 6 and Oct. 5
Direction of motion,	West to East

The law of motion is that of equal times for equal areas described from the center of the ellipse.

The corresponding rectangular coordinates of the pole of figure are,

$$x_2 = +0''.11 \sin(\odot-300°) \qquad (53)$$
$$y_2 = +0''.11 \sin(\odot-270°)$$

the origin being the pole of rotation, the positive y-axis being directed to Greenwich, the positive x-axis to longitude 270°, or 90° east from Greenwich.

From eq. (52), *A.J.* 322, we have for the fourteen months' term, at the dates 1891–3, $T_1 = 241\,1790 + 424\,E$, and $r_1 = 0''.16$. Consequently the coordinates for this term are,

$$x_1 = +0''.16 \sin(t-241\,1790)\,0°.85 \qquad (54)$$
$$y_1 = +0''.16 \cos(t-241\,1790)\,0°.85$$

Hence the resultant curve of the polar motion is defined by

(55)
$$x = +0''.16 \sin(t-241\,1790)\,0°.85 + 0''.11 \sin(\odot-300°)$$
$$y = +0.16 \cos(t-241\,1790)\,0.85 + 0.11 \cos(\odot-\quad 0)$$

The variation of latitude for a place in longitude λ, reckoned west from Greenwich, is therefore,

$$\varphi-\varphi_0 = x\sin\lambda - y\cos\lambda \qquad (56)$$

or its equivalent,

$$\varphi-\varphi_0 = -0''.16\cos[\lambda+(t-241\,1790)\,0°.85] \qquad (57)$$
$$-0''.11\cos\lambda\cos\odot + 0''.11\sin\lambda\sin(\odot-300\,)$$

2. I will now present the complete proof, only partially given in *A.J.* 323, of the eccentricity of the annual term. In the place cited I treated the eight series of latitude-determinations, between the summers of 1891 and 1892, at seven stations covering a range of 188° in longitude. The following table now gives the normal observed variations, deduced in a precisely similar way, for dates 50 days apart, from the additional series,

Series	Place	λ °	Observer	Date
IX	Berlin	−13.5	Marcuse & Battermann	1890
X	Bethlehem	+75.4	Doolittle	1890
XI	Strassburg	− 7.8	Becker	1893
XII	Bethlehem	+75.4	Doolittle	1893

all of which were by TALCOTT's method.

t	IX	X	t	XI	XII
	″	″		″	″
241 1350	−0.14	−0.16	241 2400	+0.24	+0.08
1400	− .27	.00	2450	+ .17	− .09
1450	− .26	+ .19	2500	− .01	− .15
1500	− .11	+ .24	2550	− .16	− .14
1550	+ .18	+ .18	2600	− .21	− .08
1600	+ .21	+ .02	2650	− .13	+ .02
1650	+ .20	− .19	2700	.00	+ .08
241 1700	+0.06	−0.31	2750	+ .12	+ .11
			241 2800	+0.15	+0.07

From these observed normals we find, as described in the paper alluded to, the observed values of x and y in column O of table I, which includes also the same coordinates for the interval 241 1900–2300, copied from *A.J.* 323. We thus have a nearly continuous record of the observed path described by the pole, from the beginning of 1890 to the close of 1893.

Table I.

t	x		y		Δ
	O	C	O	C	
	″	″	″	″	″
241 1350	−0.120	−0.106	+0.173	+0.146	0.030
1400	+ .067	+ .098	+ .261	+ .212	.058
1450	+ .250	+ .246	+ .206	+ .162	.044
1500	+ .260	+ .251	+ .048	+ .007	.042
1550	+ .155	+ .105	− .120	− .164	.067
1600	− .032	− .103	− .209	− .246	.080
1650	− .235	− .247	− .149	− .182	.035
1700	− .315	− .242	+ .017	− .005	.076
1750	–	− .096	–	+ .181	–
1800	–	+ .100	–	+ .264	–
1850	–	+ .231	–	+ .202	–
1900	+ .212	+ .225	− .002	+ .003	.012
1950	+ .083	+ .087	− .197	− .189	.009
2000	− .070	− .091	− .282	− .270	.024
2050	− .197	− .205	− .184	− .190	.010
2100	− .162	− .194	− .010	+ .002	.034
2150	− .041	− .074	+ .172	+ .188	.037
2200	+ .135	+ .075	+ .242	+ .259	.062
2250	+ .213	+ .165	+ .134	+ .176	.064
2300	+ .117	+ .155	− .003	− .005	.038
2350	–	+ .063	–	− .174	–
2400	+ .020	− .047	− .245	− .236	.068
2450	− .133	− .115	− .153	− .158	.019
2500	− .146	− .113	+ .031	+ .003	.043
2550	− .101	− .055	+ .176	+ .150	.053
2600	− .028	+ .013	+ .215	+ .199	.044
2650	+ .053	+ .056	+ .124	+ .131	.008
2700	+ .081	+ .065	− .012	.000	.020
2750	+ .081	+ .050	− .132	− .114	.036
241 2800	+0.033	+0.028	−0.156	−0.152	0.006

Table II.

t	x_2			y_2		
	O	C'	C	O	C'	C
	″	″	″	″	″	″
241 1350	−0.08	−0.08	−0.07	+0.02	+0.02	−0.01
1400	− .01	+ .01	+ .02	+ .12	+ .11	+ .07
1450	+ .10	+ .09	+ .10	+ .15	+ .15	+ .11
1500	+ .11	+ .13	+ .10	+ .11	+ .11	+ .08
1550	+ .09	+ .07	+ .04	+ .03	+ .02	− .02
1600	+ .02	− .03	− .06	− .06	− .06	− .09
1650	− .09	− .10	− .11	− .07	− .08	− .10
1700	− .16	− .10	− .09	− .02	− .01	− .04
1900	+ .05	+ .07	+ .06	+ .01	.00	+ .01
1950	− .03	− .03	− .03	− .08	− .08	− .08
2000	− .07	− .10	− .10	− .12	− .11	− .11
2050	− .09	− .08	− .10	− .06	− .07	− .07
2100	.00	+ .01	− .04	+ .01	+ .01	+ .02
2150	+ .09	+ .11	+ .06	+ .08	+ .08	+ .10
2200	+ .17	+ .15	+ .11	+ .08	+ .08	+ .10
2250	+ .13	+ .09	+ .09	.00	+ .02	+ .04
2300	− .04	.00	.00	− .05	− .06	− .05
2400	− .04	− .08	− .11	− .10	− .10	− .09
2450	− .08	− .06	− .06	.00	.00	− .01
2500	.00	− .02	+ .03	+ .10	+ .10	+ .08
2550	+ .05	+ .05	+ .10	+ .13	+ .14	+ .11
2600	+ .06	+ .06	+ .10	+ .08	+ .08	+ .06
2650	+ .02	+ .02	+ .03	− .03	− .03	− .03
2700	− .05	− .04	− .06	− .11	− .12	− .10
2750	− .08	− .08	− .11	− .12	− .12	− .10
241 2800	−0.08	−0.07	−0.08	−0.04	−0.04	−0.03

Abstracting the fourteen-months' term, according to eq. (54), we get the observed coordinates x_2 and y_2 which result from the annual motion alone, in the column O of table II. If these be charted it will be seen that the points fall into elliptical figures which coincide with one another in a remarkable manner, within the probable errors of observation. All of them indicate the same features, pointed out in *A.J.* 323; namely, a major axis of about 0″.3, inclined about 45° to the Greenwich meridian, a very large eccentricity, a motion from west to east, and a period of about a year. I accordingly determined by least-squares,—for each of the three intervals, A, 241 1350–1700; B, 241 1900–2300; C, 241 2400–2800,—the constants m, n, M, N, in the equations

$$x_2 = m \sin(\odot - M) \quad , \quad y_2 = n \sin(\odot - N)$$

and found

$$\begin{array}{lll} A & x_2 = & +0.''006 + 0.''113 \sin(\odot - 311.^\circ 2) \\ B & & +0.021 + 0.123 \sin(\odot - 288.6) \\ C & & -0.010 + 0.070 \sin(\odot - 310.0) \end{array}$$

$$\begin{array}{lll} A & y_2 = & +0.''038 + 0.''118 \sin(\odot - 272.^\circ 6) \\ B & & -0.010 + 0.099 \sin(\odot - 268.2) \\ C & & +0.003 + 0.135 \sin(\odot - 268.0) \end{array}$$

where the constant terms measure the distances, in the respective coordinates, of the centers of the ellipses from the pole of rotation.

To express the above results in elements of the form and position of the ellipse, we have to determine $L = \odot$ for the date T, when the pole of figure is at its maximum distance from the pole of rotation — *i. e.*, when it is at the end of the major axis; a and b, the major and minor axes; and ω the direction of the major axis. L may be found by trial from

$$m^2 \sin 2(L - M) + n^2 \sin 2(L - N) = 0$$

and the other elements by

$$\begin{aligned} a &= 2\sqrt{[m^2 \sin^2(L-M) + n^2 \sin^2(L-N)]} \\ b &= 2\sqrt{[m^2 \cos^2(L-M) + n^2 \cos^2(L-N)]} \end{aligned}$$

$$\tan\omega = \frac{m \sin(L-M)}{n \sin(L-N)}$$

We thus find, from the three intervals,

	T	L	ω	a	b
		°	°	″	″
A	April 11	20.9	44.7	0.309	0.112
B	April 1	10.6	51.4	.311	.054
C	Mar. 27	5.4	23.4	0.289	0.082

T, *L* and *ω*, have of course two values, respectively six months and 180° apart, corresponding to the two ends of the major axis.

The near agreement of these independent determinations of the elements, from observations in different revolutions, seems to me to be a demonstration, beyond reach of reasonable doubt, of the nature of the annual component of the polar motion propounded in *A.J.* 323. The values in column *C′* of table II are computed from the above expressions, *A*, *B*, *C*, for the coordinates, x_2 and y_2. Their accordance with the observed values in column *O* is very striking.

A combination of the three series, assigning double weight to the middle one, gives the values of the elements adopted in the first section of this article. From them have been computed the columns *C* in tables I and II.

In the last column of table I is given the distance between the individual observed and computed positions of the pole, or $\Delta = \sqrt{\Delta^2 x + \Delta^2 y}$. The average values for 1890, 1891,2 and 1893 are 0″.054, 0″.032, 0″.033, respectively; or for the mean of all, 0″.039. This is about the same order of magnitude as the uncertainty in the observed points themselves. But a more direct comparison with observation may be made by means of the differences O—C, of the normal observed latitude-variations of the twelve series on which the whole investigation is based, the computed values being obtained by eq. (57). These are given in table III, expressed in hundredths of a second.

Table III.

t	IX	X	*t*	XI	XII
1350	−2	−2	2400	0	+7
1400	−3	−4	2450	0	−1
1450	−3	−1	2500	−3	−4
1500	−4	0	2550	−1	−5
1550	+4	+4	2600	−1	−4
1600	−6	+6	2650	+1	0
1650	−4	+1	2700	+1	+1
1700	−1	−7	2750	+1	+3
			2800	0	+1
Mean	0.034	0.032	Mean	0.009	0.029

t	I	II	III	IV	V	VI	VII	VIII
1900	–	−7	+2	–	+10	−4	+2	−3
1950	−4	−5	+1	0	+ 1	−1	−6	−3
2000	−2	−1	+2	+3	− 2	+1	−5	+2
2050	−1	+2	+1	+4	− 5	+8	+2	+2
2100	0	+5	−1	+2	0	+7	−2	+2
2150	+2	+6	−4	0	+ 4	+2	−1	−1
2200	+3	+4	−8	−1	+11	−2	+8	−3
2250	+1	–	–	−1	+ 8	−3	−2	−2
2300	+3	–	–	−1	− 9	+3	−5	–
Mean	0.020	0.043	0.027	0.025	0.055	0.034	0.037	0.022

The mean value of a single difference, O—C, taken without regard to sign, is 0″.030. From this comparison we may reasonably conclude that the numerical theory satisfies all the observations during these four years, at stations scattered over nearly 190° of longitude, within the errors of observation. It may indeed be fairly inferred that the theory gives the numerical values of the latitude-variations with greater accuracy than they can be determined by any individual series of observations; for an examination of table III shows that the deviations for stations in the same, or nearly the same longitudes, have to a considerable extent contrary signs; so that, if we take their mean values for stations so situated, we have residuals of much smaller amount than most of the individual series show. For instance, we find:

t	Mean II, III, IV	Mean VII, VIII
	″	″
241 1900	−0.025	−0.005
1950	− .013	− .045
2000	+ .013	− .025
2050	+ .023	+ .020
2100	+ .020	.000
2150	+ .007	− .010
2200	−0.017	+ .025
241 2250	–	−0.020
Mean	0.017	0.019

The mean difference arising from the combined effect of errors in the formula, and of the mean results of two or three series is therefore only 0″.018. There is manifestly a weak tendency to system in the residuals, which may be due to slight errors in the adopted constants of the formula, or to unknown local errors of observation, or to an actual deviation, during this revolution of the pole, from its mean path. In any event, it is too trivial to found conclusions upon.

3. The accompanying diagram represents the path of the pole of figure about the pole of rotation from the beginning of 1890 to the middle of 1895, according to the formula; and also shows the deviations from the actually observed path. The top of the diagram lies towards Greenwich, 90° west longitude being towards the right. The dots on the curve, at 50-day intervals, represent the values in column *C* of table I; the small circles, connected with the corresponding points of the curve by short dotted lines, are the observed places, in column *O* of the same table. The two observed points near the center, at 2880 and 2920, are from late observations, not given in the table. If the signs of the marginal arguments be reversed, the curve will mark the movement of the pole of rotation about that of figure as the center.

As an ocular demonstration of the correctness of the theory, and its close adherence to the very involved track of the pole as shown by the observations of recent years, this diagram is very convincing. But, besides this merely illustrative purpose, it serves also a practical one; since, by means of it, we may read off with facility the variation of latitude for any desired place and dates with approximate accuracy. Thus, by drawing a line towards the longitude of the station, and dropping a perpendicular upon it from any point of the curve, the distance from the foot of the perpendicular to the center is the variation of latitude, $\varphi-\varphi_0$, on that date for that station; positive, if the perpendicular falls beyond the center; negative, if it falls between the center and the station. Perpendiculars tangent to the curve will give dates and amplitudes of maxima and minima.

For the more accurate comparison of current and future observation with theory, a table may be computed by eq. (55), and used in conjunction with eq. (56); or eq. (57) may be used directly.

4. It will have been noted that the previous results are based on the assumption that the fourteen-months' revolution is a circular one. This is what dynamical theory in its present condition seems to require, and it is the only assumption involved in the demonstration of the conclusions of this article; the rest being pure deduction from observation. For the sake of consistency, however, with the principles laid down for the conduct of these investigations (see *A.J.* XII, 68), and conscientiously followed from their beginning, it is desirable to test this assumption by directly confronting it with the observations. I have, therefore, made a solution without introducing this restriction, deriving, from the observed values of x and y in Table I, all the necessary constants for the hypothesis that both terms may be elliptical. The results are as follows:

	ω	a	b
	°	″	″
Fourteen-months' term,	281	0.345	0.298
Annual term,	43	0.333	0.087

Thus, by this unrestricted hypothesis as to the form of the fourteen-months' rotation, we get an annual ellipse practically identical in form and position with the one previously deduced, and a fourteen-months' ellipse, so nearly equivalent to the circle of $0''.16$ radius already there assumed, that it is indifferent which solution we take to represent the observations — the differences between them being merely nominal, as a strict comparison shows. The result then is to confirm practically, from these observations, the conclusion from the dynamical theory that this revolution is a circular one.

5. It may not be superfluous to point out that, while the equation for the latitude-variation (57) gives the effect of the annual motion in two terms, it may still be expressed — and for some purposes more conveniently — in a single term of the same form heretofore used, namely,

$$-r_2 \cos(\odot - G),$$

in which the constants will have particular values for each longitude, and may be found by

$$\begin{aligned} r_2 \sin G &= -m \cos M \sin\lambda + n \cos N \cos\lambda \\ r_2 \cos G &= +m \sin M \sin\lambda - n \sin N \cos\lambda \end{aligned}$$

Introducing the values adopted in this article:

$$m = n = 0''.11\ , \quad M = 300^\circ, \quad N = 270^\circ;$$

we get

$$\begin{aligned} r_2 \sin G &= -0''.0550 \sin\lambda \\ r_2 \cos G &= -0''.0953 \sin\lambda + 0''.1100 \cos\lambda \end{aligned}$$

which give the following values for the stations:

	r_2	G
	″	°
Pulkowa,	0.146	11.0
Prague,	.131	6.0
Berlin,	.130	5.7
Strassburg,	.122	3.5
Bethlehem,	.084	219.5
Rockville,	.087	218.1
San Francisco,	.147	198.4
Waikiki,	0.139	188.6

The expression $-r_2 \cos(\odot - G)$, with these constants, may be substituted for the last two terms of eq. (57).

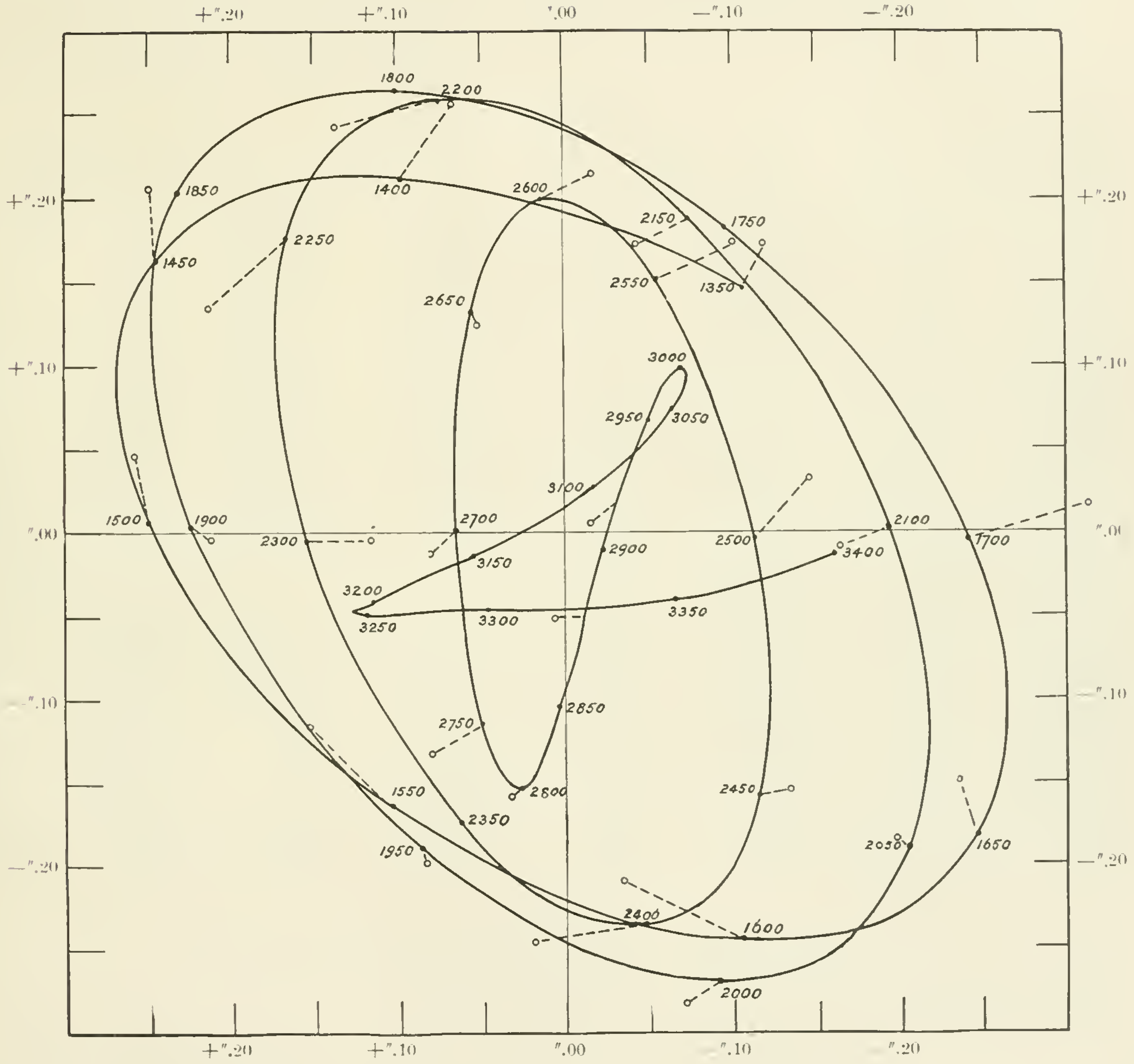
OBSERVATIONS OF 5144 *Y BOOTIS*,

By HENRY M. PARKHURST.

The period of 5144 *Y Bootis*, announced in *A.J.*, no. 326, as a variable of the *Algol*-type, seems to be 2.60514 +0.100 (sin 11°.7 E+105°) days, with the epoch April 29, 1894, (2948.526 Gr. M.T.) The unfavorable weather since this formula was obtained has prevented its satisfactory verification. On the other hand, the last observations, of Sept. 22, when the minimum itself was supposed to be lost in the twilight, did not show its proximity. The formula is founded upon the following observations, for several of which I am indebted to Mr. Yendell. The last observation of Yendell is the time deduced by myself from his observations, reduced by my own method.

E	O		Mean	Corr.	C	(O—C)
−13	2914.582	Y	0.659	−0.073	0.586	−0.004
0	2948.623	Y	.526	+ .097	.623	.000
+ 5	2961 574	Y	.552	+ .028	.580	− .006
28	3021.565	P	.470	+ .095	.565	.000
+33	3034.566	P	.496	+ .075	.571	− .005
	.579	Y	0.496	+0.075	0.571	+0.008

COMPUTED PATH OF THE EARTH'S POLE, AND COMPARISON WITH OBSERVED PLACES.



A sine-formula founded upon observations comprised within 120 days can only be an approximation, and perhaps of no more value than the suggestion that the minima may vary two hours or more from the times obtained from the mean period.

In the following table of observations, the times previous to the present year are only approximate. Comparison with the elements is too uncertain to permit their rectification, and is deferred until the elements shall have been perfected by further observations. There are anomalies needing explanation, as well as confirmatory coincidences. It is especially noticeable that in 1893, while at the minima, —106, —96, —91, and —81, the observations seem confirmatory, the intermediate period, —86, on Sept. 17, shows normal brightness. It is improbable that the uncertainty in the hour of observation will account for this; it does not seem likely that inaccuracy of the sine-formula or of mean period will; and the only conjecture that I can now offer is, that if the minima are caused by the intervention of a dark companion, its orbit may be so much inclined as to miss some of the transits. If it shall appear from further observations that a minimum is sometimes actually omitted, it may perhaps account for some of the observations of this year, and especially for the observations of Sept. 22.

INDIVIDUAL OBSERVATIONS.

5144 *Y Bootis.*

Julian	Calendar	Mag.
	1886	
0032.6	May 5	7.59
0043.64	16	8.23
0062.62	June 4	8.14
0066.61	8	8.28
.64	8	7.94
0077.61	19	8.45
0151.52	Sept. 1	8.21
.55	1	8.36_2
0152.52	2	8.39
0155.52	5	8.16_3
0161.52	11	8.10_3
0170.513	20	8.20
.517	20	8.17
.521	20	8.73
.525	20	8.23
.529	20	8.94
0182.46	Oct. 2	8.13_2
	1893	
2669.58	July 24	7.69_2
2672.58	27	8.49_2
2674.60	29	7.86_2
2675.60	30	8.03_2
2684.56	Aug. 8	7.76_2
2698.54	22	8.36_2
2703.54	27	8.17_2
2705.54	29	7.95_2
2706.54	30	8.09_2
2711.52	Sept. 4	8.31_3
2713.52	6	8.22_2
2715.52	8	7.96_2
2716.51	9	8.41_2

5144 *Y Bootis.*—Cont.

Julian	Calendar	Mag.
	1893	
2719.50	Sept. 12	8.58_2
2720.50	13	8.26_2
2723.50	16	8.81_2
2724.52	17	8.05_2
2726.50	19	7.44_2
2727.50	20	8.10_2
2728.50	21	8.02 :
2729.50	22	8.16 :
2735.50	28	8.05 :
2736.50	29	8.15 :
2737.48	30	8.98_2
2738.48	Oct. 1	8.39_2
2739.47	2	8.10_2
2740.46	3	8.35_2
2742.46	5	8.32_2
2744.46	7	8.55_2
2746.46	9	$8,66_2$
	1894	
2959.56	May 10	7.69
2961.56	12	8.48
2962.56	13	8.33
2990.55	June 10	8.44
.59	10	7.97
.62	10	7.91
2995.57	15	8.26
.61	15	8.24
.63	15	8.13
3000.58	20	8.0
.62	20	8.2
3000.65	20	8.2

5144 *Y Bootis.*—Cont.

Julian	Calendar	Mag.
	1894	
3003.55	June 23	8.54_2
.59	23	7.95
.62	23	8.21_2
.69	23	7.99
3008.55	28	8.56
.56	28	8.55
.57	28	8.01
.58	28	8.67
.61	28	8.28
.62	28	8.60
.64	28	8.25
3021.550	July 11	8.06
.557	11	8.37
.563	11	8.59
.570	11	8.36
.593	11	8.10
.600	11	7.74
.608	11	8.32_2
3034.544	24	7.85
.559	24	8,61
.563	24	8.89
.577	24	8.44
.586	24	8.27
.588	24	7.95
.606	24	8.10
3047.526	Aug. 6	7.92
.530	6	8.25
.534	6	8.07
.537	6	8.22
.541	6	8.06
3047.545	6	8.07

5144 *Y Bootis.*—Cont.

Julian	Calendar	Mag.
	1894	
3047.562	Aug. 6	8.28
.566	6	7.79
.570	6	8.11
.602	6	8.13
.606	6	8.30
.624	6	8.02
.628	6	8.37
.673	6	7.95
.678	6	8.32
3073.522	Sept. 1	8.49
.529	1	8.56
.536	1	8.72
.543	1	8.18
3094.481	22	7.6
.495	22	8.22
.498	22	7.83
.504	22	8.25
.508	22	7.90
.512	22	7.92
.515	22	8.06
.519	22	7.90
.523	22	7.78
.526	22	7.76
.531	22	8.06
.535	22	8.09
.541	22	7.99
.547	22	7.92
.551	22	7.71
3094.555	22	8.06

OBSERVATIONS OF SUSPECTED VARIABLES,

BY PAUL S. YENDELL.

(6653) —*Lyrae.*

Ten observations of this star have been obtained, from 1894 June 4 to Oct. 6. These give no decided evidence of variation, ranging from $8^M.0$ to $8^M.6$ only. The star is intensely red, my observations indicating 9.4 of CHANDLER'S scale, and in view of this fact, the reality of the indicated change appears very doubtful.

(6715) —*Lyrae.*

Eleven observations, from 1894 June 4 to Oct. 6, show an increase from $8^M.45$ to $7^M.4$. The fact that an average redness of 7.3 is indicated by my observations renders this apparent change indecisive, as in the case of (6653).

$\alpha = 19^h\ 16^m.9 \qquad \delta = +37°\ 41'$ (1900).

This star is one of Espin's stars with remarkable spectra, *A.N.* 3232, p. 267. It is not found in the DM. chart or catalogue. Espin, in his note, says, "The magnitude, 1894 April 10, was 8.5." I have three observations, as follows: 1894 June 20, $9^M.2$; July 2, $9^M.7$; Sept. 23, not seen, limit $< 11^M$.

These observations appear to prove the star's variability.

(6470) — *Ophiuchi.*

I have four observations, from 1894 July 2 to Sept. 23, as follows: July 2, $8^M.2$; Aug. 6, $8^M.3$; Sept. 23, $8^M.3$. These observations do not appear to confirm the star's variability.

$\alpha = 19^h\ 43^m.3 \qquad \delta = +21°\ 30'$ (1900).

This star is No. 887 of Espin's list in *A.N.* 3232, or DM. 21°3909, $7^M.0$. Espin gives its magnitude as $8^M.0$, and affixes the query "Var?" I have observations as follows: 1894 July 3, $7^M.85$; Aug. 26, $7^M.85$; Sept. 23, $7^M.90$. No confirmation of the star's variability is afforded by these observations.

$\alpha = 20^h\ 5^m.9 \qquad \delta = +26°\ 0'$ (1900).

No. 895 of Espin's list, above quoted. The star is DM. 25°4126, $9^M.3$.

Espin gives the magnitude as $8^M.5$, and says, "Var?" I have two observations, 1894 July 3 and Sept. 23, respectively $9^M.35$ and $9^M.20$. These give no confirmation of the star's variability.

(7240) — *Cygni.*

This star was observed on 1894 July 3, when it was compared with DM. 35°4003. $9^M.2$, and found to be 4 steps fainter than this star, and 2 steps brighter than a faint star about 3′ *nf*; its light was then estimated at $9^M.6$. No further observation was obtained until Sept. 23, when it was found about a magnitude and a half fainter than the last-mentioned star, and by eye-estimation very near $11^M.0$. There seems no doubt of its variability.

FROM A LETTER OF MR. BERBERICH TO THE EDITOR.

In the new issue of the *Jahrbuch*, the minor planets of 1894 are numbered as follows:

AV	Feb. 11	Courty	(Bordeaux)	= (384)
AX	March 1	Wolf	(Heidelberg)	= (385)
AY	March 1	Wolf	(Heidelberg)	= (386)
AZ	March 5	Courty	(Bordeaux)	= (387)
BA	March 7	Charlois	(Nizza)	= (388)
BB	March 8	Charlois	(Nizza)	= (389)
BC	March 24	Bigourdan	(Paris)	= (390)

The number 359 has been assigned to planet 1893 *M*, Charlois, March 10.

The past opposition of *Andromache* (175) will afford means for correcting the orbit of this asteroid in a sufficient manner. The corrections of the elements will be small, though there has been a great difference (40^s) between observed positions and ephemeris. A preliminary computation gave $\delta\mu = -0''.0570$. It was only the longitude of perihelion that has shifted a little.

For some time I have continued the computation of the perturbations produced by *Jupiter*, beyond the next conjunction with this planet. The following set of elements will give an idea of the transformation of the orbit.

Berlin Mean Time.

T =	1895 Nov. 26.0	1896 Dec. 30.0	1898 Mar. 15.0	1899 May 29.0	1900 May 24.0
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
M =	82 16 56.9	150 9 34.4	224 22 21.5	298 6 57.3	359 9 23.4
ω =	299 54 49.9	300 20 5.1	300 44 34.0	301 22 0.6	301 33 44.9
☊ =	25 33 58.7	25 29 53.6	25 25 4.3	25 24 47.8	25 23 51.1
i =	3 10 58.6	3 10 56.1	3 11 4.7	3 10 42.0	3 10 40.0
φ =	11 34 21.5	11 29 55.2	11 15 40.9	11 8 3.7	11 7 48.8
μ =	614″.58102	613″.13393	610″.28215	611″.64264	612″.33165
$\log a$ =	0.507618	0.508301	0.509650	0.509006	0.508680

Mean Equinox 1900.0.

From May 1900 there begins a new decrease of μ; but for some years the variation of this element will be slight until 1906, when another important diminution will follow.

I have deduced, in a rough manner, the place of *Andromache* at opposition in 1900, — first with the above elements, then with the elements osculating 1877 October. I find

$$\begin{array}{llll} \text{1900 Sept. 21.0} & \alpha = 23^h\ 47^m.3 & \delta = -4°\ \ 4'.6 \\ \qquad\quad\ \ 31.0 & \qquad 23\ \ 40.2 & \qquad -4\ \ 37.3 \end{array}$$

and

$$\begin{array}{llll} \text{1900 Sept. 21.0} & \alpha = 1^h\ \ 3^m.3 & \delta = +5°\ 14'.4 \\ \qquad\quad\ \ 31.0 & \qquad 0\ \ 55.7 & \qquad +4\ \ 39.5 \end{array}$$

The difference, -75^m and $-9°.3$, will be the effect of the perturbations in 1900.0.

A. Berberich.

Berlin, 1894 *Oct.* 23.

ON A NEW VARIABLE OF SHORT PERIOD,

18 (Fl.) *Aquilae* : (1855) $19^h\ 0^m\ 9^s$, $+10^\circ\ 51'.0$,

By S. C. CHANDLER.

Observations extending from 1894 Aug. 9 to Oct. 7 have established the variability of the above star, between the approximate limits $5^M.3$ and $5^M.7$, in a period of a trifle less than five days. The elements derived from these observations and from those of the Potsdam Photometric Catalogue are

$$1894\ \text{Aug.}\ 6.7\ (\text{Greenwich M.T.}) + 4^d.986\,E.$$

The star was used as a standard by Dr. GOULD for the *Uranometria Argentina*, and is there marked with an asterisk, which indicates that he found reason to suspect variation while it was under observation at Cordoba. It was also used as a fundamental star by MÜLLER and KEMPF: who, however, state that their numerous measurements do not confirm this suspicion (p. 482). In view of my observations, which clearly showed the above variation and its unmistakable periodicity, I was led to examine the Potsdam observations thoroughly, not only those which were taken of it as a fundamental star, but those in the zones where it was employed as such. We thus have 57 determinations of its brightness at Potsdam, on 32 nights. These were assembled to form a mean light-curve, using the above period. The result was an apparently certain confirmation of the fluctuation, within somewhat narrower limits of magnitude. This is extremely interesting as evidence of a surprising precision in the Potsdam measurements, unexampled in instrumental photometry.

OBSERVATIONS OF THE FIFTH SATELLITE OF *JUPITER*,

MADE WITH THE 36-INCH EQUATORIAL OF THE LICK OBSERVATORY.

By E. E. BARNARD.

The satellite is very faint at present, and observations of it have been obtained only on one morning. It was also seen on the morning of October 16, but a heavy south wind shaking the telescope made it impossible to set the threads on the satellite. The measures have been reduced with an apparent semidiameter (equatorial) of $20''.69$, from my previous measures of the planet (see *A.J.* 325). To this was applied a phase-correction of $-0''.38$.

The satellite was very difficult, but I think the measures will be reasonably good.

Mt. Hamilton, 1894 *Oct.* 17.

1894 *October* 8.

Standard Pac. Time	Circle	Distance from pr. limb	Distance from center
h m s	r	″	″
14 5 9	53.049	29.40	49.71
14 8 37	52.951	28.53	48.84
14 12 14	52.921	28.13	48.44
14 14 17	53.003	28.94	49.25
14 18 12	53.269	31.58	51.89
14 23 7	53.215	31.04	51.35
14 25 37	53.209	30.98	51.29
14 27 52	53.200	30.39	50.70

Coincidence of threads = $50^r.080$.

ON THE VARIABILITY OF 6442 *Z HERCULIS*,

By EDWIN F. SAWYER.

On my return the last of August from a short vacation, I found a communication from Dr. CHANDLER, calling my attention to his discovery of the above star as a variable of the *Algol*-type, and requesting observations of the same for the purpose of confirmation. Although the conditions for observing during August and September were anything but favorable, owing to recent forest fires, several observations were secured when the star was found at its normal brightness. On two occasions, however, August 29 and September 6, the star was found quite faint. On both these evenings the minimum had undoubtedly been passed, as only a few steps rise in the light was observed. These observations, however, served to prove its variability and its interesting type.

Brighton, 1894 *Oct.* 20.

POSITIONS OF COMPARISON-STAR FOR THE COMET *a* 1894,

By Dr. L. de BALL.

The comparison-star cited in no. 322 of the *Astronomical Journal*, namely S.DM. −6°259, has been twice observed here. The observations, referred to the mean equinox of 1900.0, are

			M	h m s	° ′ ″	
1892 Mar. 21	=	1892.22	8.7	8 21 27.37	−6 8 43.8	Circle W.
1893 Mar. 16	=	1893.20	8.6	27.46	44.6	" E.

v. Kuffner Observatory, Vienna XVI, 1894 *July* 22.

REDISCOVERY OF ENCKE'S COMET.

ENCKE's periodical comet was discovered by CERULLI at Teramo on Nov. 1. Its position at Berlin noon Nov. 4, was $\alpha = 23^h\ 8^m\ 8^s$, $\delta = +13^\circ\ 36'$. Daily motion, $-2^m\ 16^s$ in α, and $16'$ southward.

NOTE FROM PROF. SAFFORD TO THE EDITOR.

Allow me to add some notes to Mr. DAVIS's excellent paper in *A.J.* 328.

1). The Åbo catalogue is already brought up to 1830 with its own proper motions, as was then the fashion among the better astronomers. It is not, then, quite proper to speak of the epoch 1830 as *erroneous*. ARGELANDER himself usually employed 1830 in place of computing the mean year.

2). Some of the additional stars mentioned in the article are to be found in STRUVE's *Breitengradmessung*, as observed by ARGELANDER and STRUVE himself. Others are, I think, in ARGELANDER's article in the *A.N.* on FAMSTEED's stars not in his (F.'s) catalogue.

3). The fourth volume of the Åbo observations was never published. There is, however, a copy of the sheets in the Harvard College Observatory library. I think it is not often to be met with; this copy was bought at my request about thirty years ago, and I cannot remember that I have ever seen another one offered for sale. Mr. DAVIS has performed a real service to astronomers; as no other astronomer but the author has, so far as I know, ever had this fourth volume at command when calculating epochs for proper-motion stars.

Williamstown, Mass., 1894 *Oct.* 27.

T. H. SAFFORD.

NEW ASTRONOMICAL WORKS.

Formeln und Hülfstafeln für Geographische Ortsbestimmungen, von Prof. Dr. TH. ALBRECHT. *Dritte umgearbeitete und vermehrte Auflage.* Leipzig, WILHELM ENGELMANN, 1894.

This enlarged, and to a considerable extent rewritten, edition of the well-known work of Prof. ALBRECHT, contains a theoretical discussion of the formulas generally required for geographical determinations, together with the principal tables needful for their employment. It also constitutes a valuable handbook for those engaged in geodetic operations, and gives the latest adopted values for the constants. Four-figure tables of the logarithms of numbers and trigonometrical functions are added; as well as the numerical values of the latter.

Verzeichniss der Elemente der bisher berechneten Cometenbahnen, nebst Anmerkungen und Literatur-Nachweisen. neu bearbeitet, ergänzt und fortgesetzt bis zum Jahre 1894, *von* Dr. J. G. GALLE. Leipzig, W. ENGELMANN.

Forty-seven years have elapsed since the astronomer GALLE, then at the Berlin Observatory, prepared for ENCKE's edition of OLBERS's treatise on the Computation of a Comet-orbit, a table of the elements of all the comet-orbits, which had been deduced up to that date, 178 in number, and with numerous valuable references; this being a continuation and completion of OLBERS's own catalogue published in SCHUMACHER's *Astronomische Abhandlungen.*

For the third edition of "OLBERS's Method," published 1864, GALLE continued his catalogue up to the end of 1863, in an appendix which was also separately issued. More than twenty years later yet, in April 1885, he published in the *Astronomische Nachrichten*, vol. 112, another list, containing the orbits of seventy more comets, making 286 in all, forty-two of which were newly computed or corrected.

The present catalogue is far more elaborate than its predecessors. It is a volume of 315 pages, containing the orbits of 416 comets, each apparition of a periodic comet being separately numbered. In the arrangement of the table of Elements a few changes have been made, mostly in conformity with the usage of recent years. The times of perihelion passage are given in decimals of a day; the inclinations are counted from 0° to 180°, thus dispensing with the distinction between direct and retrograde motion; instead of π, the so-called longitude of the perihelion, the angle $\omega = \pi - \Omega$ is given, under the title "Argument of the Perihelion," in analogy with the "Argument of the Latitude," u.

The historical narratives and references are very complete, and the work is thus a repertory, which, in the present condition of our knowledge, seems almost indispensable.

The gratitude of astronomers is due to the honored veteran who signalized his twenty-fourth year by the discovery of *Neptune*, and his eighty-second by this important work.

CORRIGENDA.

No. 325, p. 101, col. 2, line —16, *for* "the stars," *put* "two stars."; p. 102, table of diameters. July 8, *for* 42″.87 *put* 40″.87.

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OBSERVATIONS OF VARIABLE STARS,

By WM. MAXWELL REED.

[Communicated by EDWARD C. PICKERING, Director of the Harvard College Observatory.]

The following summary of observations must be considered preliminary to a final discussion to be published in the Annals of the Harvard College Observatory. The magnitudes were derived from a combination of the light-scales and meridian-photometer measurements. In some cases, however, where M. P. magnitudes were not available DM. estimates were used. The magnitudes above the ninth will not be materially altered by the final discussion. The fainter magnitudes may be corrected by as much as one unit. Any systematic correction upon the scales of magnitudes, however, will have little effect upon the times of maxima, minima, and secondary phases.

All observations, from July 16, 1890, until Feb. 10, 1894, were made at the Harvard College Observatory with the West Equatorial ($6\frac{1}{4}$-inch aperture). After Feb. 10 the observations were made by the telescope of the Abbot Academy ($5\frac{1}{16}$-inch aperture) at Andover, Mass.

I wish to thank the Board of Trustees, and Miss Laura Watson, Principal of the Academy, for generously placing the apparatus of their observatory at my disposal.

To describe a small notch or irregularity in the light-curve I have used the word "stand-still," which has already been suggested in a contemporaneous publication. To economize space it has been abbreviated as "SS." This term has frequently been used to denote a temporary decrease in the rate of change in the light of the variable, although there was not the slightest evidence that the magnitude of the star actually "stood still" a moment.

The study of the irregularities in the light-curve is fully as interesting as of those in the period. The character of the light-curve in connection with changes in the spectrum may give results as valuable as those derived from the irregularities in the period and proper motion of *β Persei*. An interesting example is *S Cephei*. The usual form of maximum as given by these observations is a somewhat rapid increase and decrease; but at the apex, for a hundred or more days, there is scarcely any change in the light. The star also remains at practically the same magnitude for fifty or more days at minimum. The maximum on 1891 Dec. 12 had the usual increase, but a sharp apex and a gradual decrease. The principal feature was a sudden outburst of light which occurred during the decrease. The variable increased more than a magnitude in a week. A month or so later, however, it had decreased to the brightness it would have had if the outburst had not occurred. So that this secondary maximum gives the appearance of being a mere addition to the light-curve. Several other secondary phases are indicated, but there are not enough observations to establish them with certainty. A great many of the "stand-stills" recorded in the following notes present the same phenomenon of being additions to the light-curve. A record of over ten years for *T Cephei* gives ten more or less well-determined "stand-stills." The mean period is about twenty days less than that of the variable. From studying these and other variables, I am inclined to believe that the light-curve, in some cases at least, is the sum of two or more curves — each component curve having a different range, period, and character from the others. By such a hypothesis one can account for the changes in period and range of a variable, and the presence of "stand-stills" and secondary phases. Unfortunately there is not enough evidence yet to give the elements of the two or more component curves for *T Cephei*.

Such a problem is sure to be solved in the course of time by a sufficient number of observations. But heretofore the preliminary publications on variable stars have consisted chiefly of data for the period, and a casual description of the character of the curve. Observers have deferred a discussion of the light-curve for such final publications as have been made by ARGELANDER, SCHÖNFELD, PEEK, PARKHURST, and others. Such elaborate publications must necessarily occur at long intervals of time; so that half a century may elapse before all the observations of a given decade are published. If the study of the periods had been dependent upon such material, our present ephemerides would have had little value. I do not wish to impair in the least the importance of publications of the original observations in the manner followed. But I think the character of the light-curve should receive the same amount of attention in the preliminary publications as has been given to the period. That I might not pose as a guide-post, I had intended to set a little stronger example than I have, by publishing the coordinates of numerous points on the light-curves. But the publication of the original observations and deduced light-curves will be made so soon by Harvard College Observatory, that the above plan would have caused useless duplication of work. *R Aurigae* is given, however, as an example of how economically the phases of the light-curve can be published in a preliminary article.

The dates, except when in brackets, are in the Julian day. The magnitudes given for the beginning and end of the different series of observations are taken from the light-curve, and not from individual observations.

T Cassiopeae.

Max. 241 1636 [1890 Sept. 25] at $7^{M}.3$, 29 observations. The variable was $8^{M}.8$ when first observed on 241 1575, and $11^{M}.0$ when last observed 241 1805. The decrease of the curve was practically a straight line.

Max. 241 2088 [1891 Dec. 21] at $7^{M}.5$, 37 observations. A secondary maximum occurred at 241 1961 at $8^{M}.6$. Observations were commenced on 241 1900 at $9^{M}.2$, and ended on 241 2200 at $9^{M}.9$. The decrease was best represented by a straight line.

S Cassiopeae.

Max. 241 1932 [1891 July 18] at $7^{M}.8$, 22 observations, which were commenced 241 1882 at $9^{M}.7$, and ended on 241 2098 at $11^{M}.0$. Both the increase and decrease were represented by straight lines.

T Persei.

From 241 1630 to −930, 34 observations show no variation in the light of the variable, which remained constant at the $9^{M}.0$. A very slight maximum was passed on 241 1990 at $8^{M}.7$; 15 observations. The star then remained constant at $9^{M}.1$ from 241 2100 to 210; 7 observations. From 241 2400 to 555, 4 observations, the variable was $9^{M}.2$. From 750 to 905, 8 observations, the variable was $9^{M}.1$.

S Persei.

Max. 241 2180 [1892 March 22] at $8^{M}.3$; 92 observations. At 241 1640 the variable was $10^{M}.3$. The increase was slow until 241 1815, when it began to increase rapidly until 241 1950 at $8^{M}.5$. The variable then remained very nearly stationary until 80 days before maximum. The decrease was regular, and at about the rate of 1 unit in 90 days.

Min. 241 2500 [1893 Feb. 5] at $10^{M}.3$; 41 observations. For more than 200 days at minimum the variable remained stationary in brightness, so that the above date is necessarily approximate. The increase was at the same rate as the decrease of the previous maximum. On 241 2880 the star reached the $9^{M}.0$.

R Aurigae.

Max. 241 1587 [1890 Aug. 7] at $7^{M}.3$. Only one observation was made during increase, so that the time of maximum is a little uncertain. But since there were 5 observations at maximum, there is excellent evidence that the above date, if in error at all, is too late. A slight "SS." occurred during the decrease at about $11^{M}.3$, and 150 days after maximum. The variable was $9^{M}.0$ on 241 1565; $7^{M}.4$ on 581 and 596; $8^{M}.0$ on 632; $9^{M}.0$ on 672 $10^{M}.0$ on 699; $11^{M}.0$ on 718; $11^{M}.2$ on 724; $11^{M}.3$ on 745; $12^{M}.0$ on 774; 21 observations.

Max. 241 2037 [1891 Oct. 31] at $6^{M}.9$. The increase was marked as usual by a prominent "SS." at $10^{M}.3$. The "SS." began about 110 days before maximum, and lasted about 30 days. As in the previous epoch, the observations indicate a slight "SS." about 150 days after maximum, and at $11^{M}.3$. But unfortunately observations were stopped at this point, so that its presence can not be considered proved. The variable was $12^{M}.3$ on 241 1865; $10^{M}.3$ on 924 and 945; $10^{M}.0$ on 973; $9^{M}.0$ on 999; $8^{M}.0$ on 241 2011; $7^{M}.5$ on 020 and 062; $8^{M}.0$ on 079; $9^{M}.0$ on 113; $10^{M}.0$ on 145; $11^{M}.0$ on 174; $11^{M}.3$ on 201; 28 observations.

Max. 241 2523 [1893 Feb. 28] at $7^{M}.3$. Observations on the increase were commenced at $9^{M}.6$ in the middle of the "SS.," which ended about 110 days before maximum. The variable was $9^{M}.6$ on 241 2400 and 415; $9^{M}.3$ on 430; $8^{M}.5$ on 461; $7^{M}.5$ on 500 and 545; $8^{M}.5$ on 578; $9^{M}.2$ on 595; 11 observations.

Max. 241 2950 [1894 May 1] at $6^{M}.9$. The time of maximum depends upon only 5 observations, and is therefore a little uncertain. The "SS." on the increase occurred at $9^{M}.6$. It began 115 days before maximum, and lasted about 60 days. The variable was $11^{M}.9$ on 241 2780; $11^{M}.0$ on 800; $10^{M}.0$ on 820; $9^{M}.6$ on 835 and 890; $9^{M}.4$ on 905; $8^{M}.5$ on 921; $7^{M}.7$ on 985; $8^{M}.7$ on 241 3016; 12 observations.

R Lyncis.

Max. 241 1867 [1891 May 14] at $8^{M}.3$; 22 observations. Two secondary maxima follow the principal one by about 40 and 75 days respectively.

R Ursae Majoris.

Max. 241 1856 [1891 May 3] at $8^{M}.0$; 19 observations. The increase of the curve was rapid. The variable changed slowly at maximum. Observations extend from 241 1766 at 12^{M}.5 to 241 1985 at 12^{M}.1.

Max. 241 2159 [1892 March 1] at 7^{M}.4, 16 observations, which extend from 241 2129 at 7^{M}.9 to 241 2212 at 9^{M}.3.

Max. 241 2449 [1892 Dec. 16] at 7^{M}.6; 7 observations. The character of the light-curve was the same as for the maximum 1891 May 3. Observations extend from 241 2406 at 9^{M}.8 to 241 2539 at 10^{M}.7.

Max. 241 2749 [1893 Oct. 12] at 7^{M}.9; 15 observations. The time of maximum is a little uncertain because there were only 3 observations during the increase. Observations extended from 241 2698 at 10^{M}.3 to 241 2837 at 10^{M}.5.

T Ursae Majoris.

Max. 241 2041 [1891 Nov. 4] at 8^{M}.0, 7 observations, which began on 241 1985 at 11^{M}.7, and ended on 241 2097 at 10^{M}.1.

Max. 241 2829 [1893 Dec. 31] at 7^{M}.7; 9 observations. The increase was slower than the decrease. Observations began on 241 2766 at 9^{M}.6, and ended on 922 at 12^{M}.4. The time of maximum may be a little too early.

S Ursae Majoris.

The successive maxima were so nearly alike that all the observations were united into one curve. A “SS.” of about 25 days’ duration occurred on the increase at 8^{M}.4. It began about 48 days before maximum. The variable at maximum was 7^{M}.8, and at minimum 11^{M}.5. The weights are in proportion to the number of observations.

Observed Maxima			O—C	Wts.
241 1705.4	=	1890 Dec. 3.4	−1.3	5
241 1932.6		1891 July 18.6	+1.1	7
241 2154.9		1892 Feb. 25.9	−1.1	13
241 2379.8		1892 Oct. 7.8	−0.2	12
241 2605.0		1893 May 21.0	+1.2	1
241 2825.4	=	1893 Dec. 27.4	−1.8	5

Observed Minima			O—C	Wts.
241 1589.5	=	1890 Aug. 9.5	−4.2	2
241 1825.2		1891 Apr. 2.2	+6.7	17
241 2041.5		1891 Nov. 4.5	−1.5	4
241 2266.5		1892 June 16.5	−0.6	7
241 2496.5		1893 Feb. 1.5	+5.7	2
241 2705.3		1893 Aug. 29.3	−8.7	3
241 2932.3	=	1894 Apr. 13.3	−4.8	3

The mean by weights of the residuals for maxima is $-0^{d}.54$, and for minima $+1^{d}.7$. These corrections do not justify any change in the elements.

S Bootis.

					Extent of Observations			
Epoch	Observed Maxima		Mag.	No. Obs.	Began	Mag.	Ended	Mag.
37	241 1646	1890 Oct. 5	8.4	14	241 1592	10.0	241 1733	11.0
38	241 1909	1891 June 25	8.1	15	241 1823	11.5	241 1969	10.0
39	241 2178	1892 Mar. 20	8.6	15	241 2103	11.0	241 2205	9.0
40	241 2439	1892 Dec. 6	8.0	9	241 2368	10.5	241 2537	11.2
42	241 2965	1894 May 16	8.3	10	241 2902	10.0	241 3045	11.0

The above maxima indicate a steady decrease in the length of the period. The decrease began apparently at the 36th epoch, and amounted to 13 days at the 42d. By a curious coincidence, a small break in the observations occurred at or near each maximum. The observations therefore do not actually contradict the elements.

R Camelopardalis.

Max. 241 1768 [1891 Feb. 4]; 15 observations. The magnitude at maximum is uncertain on account of lack of observations. For the same reason the determination of time is doubtful by 3 or 4 days. Observations extended from 241 1684 at 12^{M}.0 to 241 1877 at 11^{M}.0.

Max. 241 2032 [1891 Oct. 26] at 7^{M}.6; 20 observations. There were two “SS.’s” during decrease. The first occurred approximately, from 48 to 63 days after maximum, and at 8^{M}.9. The second began about 88 days after maximum, and lasted about 14 days at 10^{M}.1. Observations from 241 1952 at 12^{M}.2 to 241 2182 at 12^{M}.2.

Max. 241 2297 [1892 July 17] at 8^{M}.4; 20 observations. The observations from 241 2270 to −384 were made by Mr. T. E. Powe. On account of the flatness of the curve at this epoch, which forms a striking contrast to the previous one, the time of maximum cannot be determined with precision. Observations from 241 2236 at 10^{M}.3 to 241 2428 at 11^{M}.4.

Max. 241 2836 [1894 Jan. 7] at 8^{M}.1; 13 observations. The observations indicate a “SS.” during the increase at 10^{M}.7, and about 90 days before maximum.

R Ursae Minoris.

A maximum was indicated about 241 1620 [1890 Sept 9] at 9^{M}.2. But observations were commenced too late to make this determination at all certain.

Min. 241 1717 [1890 Dec. 15] at 10^{M}.1
Max. 241 1923 [1891 July 9] at 9^{M}.2

The increase was very gradual, while the decrease was in comparison rapid. To change $\tfrac{7}{10}{}^{M}$ (max. to 9^{M}.9) took before maximum 152 days, and after maximum only 47 days.

Min. 241 2053 [1891 Nov. 16] at $10^{M}.05$. The light-curve was very flat at this minimum. For 100 days' observations indicate scarcely any change in light.

The above times of maxima and minima were derived from 60 observations.

R Draconis.

Epoch 20. Max. 241 1624 [1890 Sept. 13] at $8^{M}.1$; 17 observations. The grouping of the observations makes the date of maximum not so accurately determined as for the following epoch. Observations from 241 1573 at $11^{M}.5$ to 241 1690 at $11^{M}.0$.

Epoch 21. Max. 241 1873.5 [1891 May 20.5] at $7^{M}.1$; 20 observations, from 241 1807 at $11^{M}.0$ to 241 1960 at $12^{M}.0$.

Epoch 22. Max. 241 2118 [1892 Jan. 20]; 15 observations. With the exception of two observations near minimum, only the decrease was observed. It resembled so closely the decrease of Epoch 21, that I assumed that the two curves were alike in other respects, and accordingly computed the above time of maximum.

Epoch 23. Max. 241 2363 [1892 Sept. 21]; 5 observations. Only the decrease was observed for this epoch also. The time of maximum was computed in the same manner as for epoch 22.

Epoch 25. Max. 241 2853 [1894 Jan. 24] at $7^{M}.6$; 6 observations.

When all the observations were united into a single curve, a slight "SS." was indicated on the decrease at $10^{M}.7$, 60 days after maximum. It was noticeable only in Epochs 20, 22, 23, 25.

S Cygni.

Max. 241 2765 [1893 Oct. 28] at 10.5; 10 observations. The light-curve, as is well known, is slightly irregular. A "SS.," or perhaps a secondary minimum, occurred about 12 days before maximum at $10^{M}.8$. Observations extended from 241 2739 at $12^{M}.0$ to 241 2802 at $12^{M}.2$.

T Cephei.

Min. 241 1707 [1890 Dec. 5] at $8^{M}.6$; 20 observations, from 241 1583 at $6^{M}.2$ to 2411780 at $7^{M}.7$.

Max. 241 1931 [1891 July 17] at $5^{M}.4$; 22 observations, from 241 1792 at $7^{M}.3$ to 241 2018 at $7^{M}.5$. The increase was marked by two slight "SS.'s." The decrease could best be represented by a straight line.

Min. 241 2138 [1892 Feb. 9] at $10^{M}.4$; 10 observations. Since the variable was not observed between 241 2119 and 241 2162, the date of minimum is somewhat doubtful. If the date is in error at all, it is probably too late. Observations extended from 241 2037 at $8^{M}.0$ to 241 2166 at $8^{M}.0$.

Max. 241 2336 [1892 Aug. 25] at $5^{M}.4$; 22 observations. All observations above $6^{M}.6$ were made by Mr. T. E. Powe. During the increase there was one prominent "SS." Observations extend from 241 2175 at $7^{M}.5$ to 241 2400 at $7^{M}.5$.

Min. 241 2515 [1893 Feb. 20] at $9^{M}.7$; 6 observations. Both date and magnitude are uncertain, for only one observation was made on the increase. As with the previous minimum, the date cannot well be later.

Min. 241 2875 [1894 Feb. 15]; 12 observations, from 241 2785 at $7^{M}.5$ to 241 2955 at $7^{M}.6$.

R Cassiopeae.

The character of the light-curve, so far as these observations extend, is the same for successive maxima. The increase is slightly concave; the decrease is more gradual, and slightly convex. Each maximum presents the appearance of a blunted cusp of slight curvature.

Max. 241 1735 [1891 Jan. 2] at $6^{M}.2$; 17 observations, from 241 1570 at $12^{M}.2$ to 241 1816 at $7^{M}.0$.

Min. 241 2005 [1891 Sept. 29] at $11^{M}.2$; 15 observations, from 241 1921 at $9^{M}.5$ to 241 2097 at $9^{M}.0$.

Max. 241 2164 [1892 March 6] at $5^{M}.4$; 18 observations, from 241 2117 at $8^{M}.0$ to 241 2308 at $8^{M}.0$.

Min. 241 2436 [1892 Dec. 3] at $11^{M}.1$; 13 observations, from 241 2327 at $8^{M}.5$ to 241 2495 at $10^{M}.0$.

Min. 241 2841 [1894 Jan. 12] at $11^{M}.5$; 16 observations, from 241 2710 at $8^{M}.3$ to 241 2978 at $8^{M}.5$.

U Cassiopeae.

Min. 241 2960 [1894 May 11] at approximately $11^{M}.0$; 19 observations. The decrease was rapid until about $10^{M}.5$, when the variable began to change very slowly. It took it more than 150 days to pass through the remaining half-magnitude. The increase was very rapid.

U Persei.

Max. 241 2951 [1894 May 2] at $8^{M}.5$; 8 observations. The curve was very flat at maximum, which makes the above date approximate. Observations began 241 2845 at $9^{M}.0$, and ended 241 3026 at $9^{M}.4$.

o Ceti.

Min. 241 2785 [1893 Nov. 17] at $9^{M}.0$; 15 observations, from 241 2746 at $8^{M}.6$ to 241 2837 at $8^{M}.0$.

1279 — *Camelopardalis.*

In No. 296 of this Journal, I published the results from 18 months' observations of this star. Since there were no changes in the brightness that could not be accounted for by the great redness, I concluded the star was not variable. In the autumn of 1893 the star was again placed under observation. Slight changes were noticed independently by both Mr. Wendell with the East Equatorial, and by myself with the West Equatorial. But the first decided variation that I have observed occurred in the spring of 1894. There was a slight minimum on about 241 2922 [1894 April 3] at 8$^{\rm M}$.2, a decrease of about half a magnitude from the usual brightness. Since the variability of this star is in dispute, and since there is very properly a tendency to ascribe all announcements of variations to errors caused by redness, I will give the observations for this minimum in detail.

J.D.	Date	Magn.	J.D.	Date	Magn
241 2841	1894 Jan. 12	7.52	241 2918	1894 Mar. 30	8.05
241 2858	" Jan. 29	7.70	241 2921	" Apr. 2	8.28
241 2892	" Mar. 4	7.67	241 2945	" Apr. 26	8.07
241 2907	" Mar. 19	7.69	241 2951	" May 2	8.26
241 2912	" Mar. 24	7.85	241 2971	" May 22	7.86
241 2915	" Mar. 27	8.14	241 3017	" July 7	7.66

S Camelopardalis.

Max. 241 2916 [1894 March 28] at 8$^{\rm M}$.3; 4 observations, from 241 2890 at 8$^{\rm M}$.9 to 241 2965 at 8$^{\rm M}$.9.

S Canis Minoris.

Max. 241 2871 [1894 Feb. 11] at 7$^{\rm M}$.9; 12 observations. The increase and decrease were both rapid, and so far as observed, at about the same rate. Observations extended from 241 2755 at 11$^{\rm M}$.1 to 241 2950 at 9$^{\rm M}$.3.

R Leonis.

Min. 241 2811 [1893 Dec. 13] at 10$^{\rm M}$.2; 7 observations, from 241 2753 at 8$^{\rm M}$.4 to 241 2848 at 9$^{\rm M}$.5. The curve was very regular.

V Leonis.

Max. 241 2915 [1894 March 27] at 8$^{\rm M}$.2; 8 observations. Time of maximum uncertain. The variable was first seen on 241 2891 at 9$^{\rm M}$.3, and last seen on 241 2976 at 12$^{\rm M}$.0.

U Bootis.

Six observations indicate a maximum at 241 2916 [1894 March 28] at about 9$^{\rm M}$. Observations from 241 2854 to 241 2958 at 10$^{\rm M}$.5.

R Herculis.

Max. 241 2916 [1894 March 28] at 8$^{\rm M}$.3; 13 observations. So far as observed the increase and decrease were at the same rate, and very regular. Observations commenced at 241 2890 at 9$^{\rm M}$.2. The last observation reduced was on 241 2984 at 10$^{\rm M}$.3.

X Scorpii.

Max. 241 2928 [1894 April 9] at 9$^{\rm M}$.9; 5 observations. There are not enough observations to give the time of maximum with precision. Since the computed time was 54 days too late [the variable was then below the 12$^{\rm M}$.0] the maximum will serve as a rough correction to the elements. First observation on 241 2892 at 11$^{\rm M}$.5; last observation on 241 2976 at 11$^{\rm M}$.7.

χ Cygni.

Max. 241 2777.5 [1893 Nov. 9] at 4$^{\rm M}$.9; 23 observations. The observations were made as numerous, and with as much care as possible, in order to compare them with those made by photometer R. with the East Equatorial (15-inch aperture), to determine whether or not slight irregularities exist in the light-curve at maximum. No irregularities, however, were established. This series of observations has a mean deviation from its own light-curve of $\pm 0^{\rm M}.06$. Observed light-curve extends from 241 2751 at 5$^{\rm M}$.9 to 241 2848 at 7$^{\rm M}$.3.

U Cygni.

Max. 241 2849 [1894 Jan. 20] at 8$^{\rm M}$.5; 15 observations. There is a break in the series of observations of about 70 days, commencing at the above date of maximum. If the light-curve is regular, this will not materially affect the time of maximum. But, even if there were a sudden rise during this interval of no observation, the computed time of maximum must be at least 40 days too late. Observations extended from 241 2557 at 9$^{\rm M}$.5 to 241 2985 at 9$^{\rm M}$.6.

ELEMENTS OF THE POLAR MOTION FROM ALL PUBLISHED OBSERVATIONS, FROM 1889.0–1894.5,

By S. C. CHANDLER.

Since the article in *A.J.* 329 was printed, Prof. Albrecht's Report prepared for the International Geodetic Association has been received, giving the results of hitherto unpublished observations, including series at Kasan and Karlsruhe, by Talcott's method, and the continuation of those at Strassburg and Bethlehem. In view of these important accessions I have thought it desirable to make a determination of the elements of the polar motion from all the available material. A brief account of the results is here submitted.

The fourteen-months' term, according to the first term of eq. (57), was subtracted from the observed latitudes for all the series, as given in the report mentioned. The constants r_2 and G' were then found, from the whole series at each station, as given in columns 3 and 5 in the following table:

1	2	3	4	5	6	7	8	9	10	11	12	13
		r_2		G'		$r_2 \sin G'$		$r_2 \cos G'$			Circular Hypothesis	
Station	λ	O	C	O	C	O	C	O	C	Wt.	$r_2 \sin G'$	$r_2 \cos G'$
	°	″	″	°	°	″	″	″	″		″	″
Kasan	− 49.1	0.073	0.110	385.5	373.7	+0.032	+0.026	+0.066	+0.107	7	+0.036	+0.080
Pulkowa	30.3	.077	.104	364.8	366.6	+ .007	+ .012	+ .077	+ .103	12	+ .008	+ .087
Vienna	16.4	(.048)	.093	(306.8)	360.6	(− .038)	+ .001	(+ .029)	+ .093	0	− .013	+ .086
Prague	14.4	.072	.091	371.4	359.4	+ .014	− .001	+ .070	+ .091	10	− .016	+ .086
Berlin	13.5	.104	.090	367.0	358.7	+ .013	− .002	+ .104	+ .091	13	− .017	+ .085
Potsdam	13.1	.072	.090	332.0	358.7	− .032	− .002	+ .064	+ .090	4	− .017	+ .085
Karlsruhe	8.4	.072	.084	367.3	355.9	+ .009	− .006	+ .072	+ .084	6	− .025	+ .084
Strassburg	− 7.8	.119	.084	354.5	355.9	− .011	− .006	+ .119	+ .084	15	− .026	+ .083
Bethlehem	+ 75.4	.076	.073	231.6	219.4	− .059	− .046	− .047	− .056	10	− .086	− .016
Rockville	77.1	.158	.075	199.6	218.0	− .053	− .046	− .149	− .059	4	− .085	− .018
San Francisco	122.9	.111	.109	166.5	196.4	+ .026	− .031	− .108	− .105	4	− .047	− .074
Waikiki (*M*)	157.8	.114	.098	171.2	182.9	+ .017	− .005	− .112	− .098	4	+ .004	− .087
Waikiki (*P*)	+157.8	0.134	0.098	185.5	182.9	−0.013	−0.005	−0.133	−0.098	4	+0.004	−0.087

The corresponding values of $r_2 \sin G'$ and $r_2 \cos G'$ are given in columns 7 and 9, and their weights in column 11. These weights have been slightly modified from the computed values, and those for Strassburg, Berlin and Pulkowa, augmented to correspond to their presumed greater intrinsic precision. Using columns 7 and 9 as the absolute terms in the equations

$$+\mu \sin\lambda - \nu \cos\lambda = r_2 \cos G'$$
$$-\mu' \sin\lambda + \nu' \cos\lambda = r_2 \sin G'$$

where $\mu = m \sin M \qquad \nu = n \sin N$
$\mu' = m \cos M \qquad \nu' = n \cos N$

(see Sections 2 and 5, *A.J.* 329), we find

$$m = 0''.0894 \qquad M = 299^\circ.9$$
$$n = 0\;.0750 \qquad N = 260\;.4$$

whence we derive the elements of the ellipse

$$a = 0''.22$$
$$b = 0\;.08$$
$$\omega = 50^\circ.7$$
$$L = 12.2 \text{ and } 192^\circ.2$$
$$T = \text{April 3 and Oct. 2}$$

Comparing these with section 1, *A.J.* 329, we find an essential agreement, except in the major axis; even this difference will cause no surprise, considering the delicacy of the problem.

The corresponding computed values are given in columns 4, 6, 8 and 10. For the latitude-variation we have, (58)

$$\varphi - \varphi_0 = -0''.16 \cos[\lambda + (t - 241\,1790)\,0^\circ.85]$$
$$-0''.075 \cos\lambda \cos(\odot - 350^\circ) + 0''.09 \sin\lambda \sin(\odot - 300^\circ)$$

which perhaps deserves preference over eq. (57), from the ampler basis of observation on which it rests.

For the last two terms of this equation we may substitute

$$-r_2 \cos(\odot - G')$$

using the constants found from

$$r_2 \sin G' = -0''.045 \sin\lambda - 0''.012 \cos\lambda$$
$$r_2 \cos G' = -0\;.078 \sin\lambda + 0\;.074 \cos\lambda$$

as explained in section 5, *A.J.* 329.

A comparison of this formula with the individual series gives an accordance eminently satisfactory throughout. This is illustrated by the accompanying chart. To show how slight are the symptoms of any systematic departure from the law, I give below the mean values of the differences, for normal dates 50 days apart, from the mean of the eight European series. The first column is the Julian date diminished by 241 0000; the second is the mean value of O−C in hundredths of seconds; the third is the number of the series on which each is based.

1100	+3	3	1750	−2	3	2400	0	4
1150	−4	3	1800	+1	3	2450	−3	5
1200	−1	3	1850	+3	3	2500	−1	5
1250	−1	3	1900	+1	3	2550	+3	5
1300	+1	3	1950	+1	4	2600	+2	5
1350	−5	3	2000	+3	4	2650	−4	5
1400	−7	3	2050	+3	4	2700	0	4
1450	−4	3	2100	0	4	2750	−1	4
1500	0	3	2150	+4	4	2800	−1	4
1550	−2	3	2200	+2	4	2850	−1	3
1600	−3	3	2250	0	4	2900	+2	3
1650	−5	3	2300	−3	3	2950	0	3
1700	−2	3	2350	−1	3	3000	+1	3

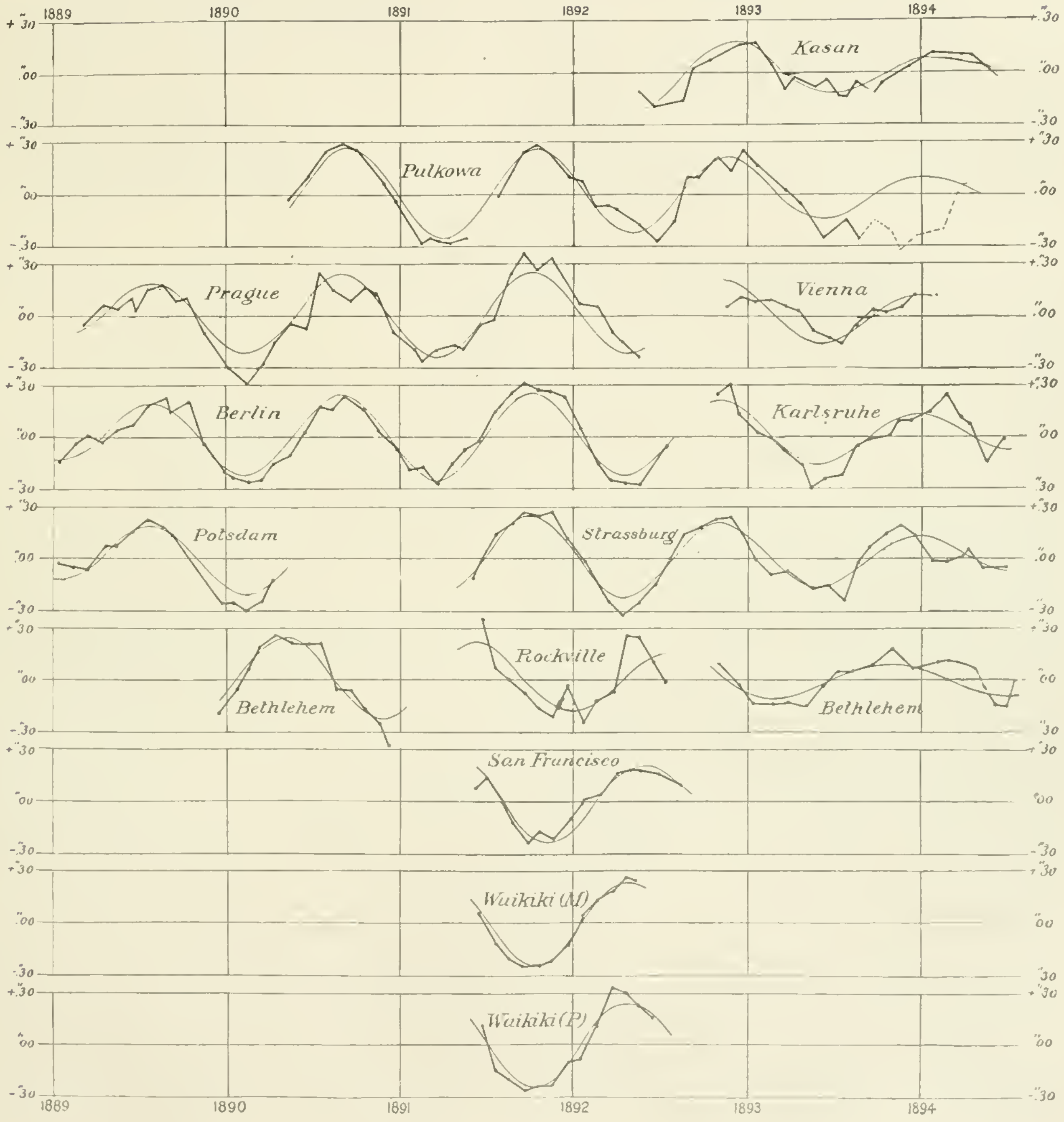
The mean deviation is ±0″.022, which is the combined effect of the error of the formula and of the mean of from 3 to 5 series. It appears to be a legitimate and conservative inference that the numerical theory follows the phenomenon throughout its whole observed course closer than any individual series of observations can do. We are also warranted in relying with considerable confidence upon prediction as to its future course, based on this theory.

On the hypothesis of circular motion we shall find that the values which best satisfy the observations are,

$$r_2 = 0^\circ.087 \qquad G' = 335^\circ.0 - \lambda$$

whence we find columns 12 and 13 of the table. If, with the values of λ in column 2 as abscissas, we plot columns 7, 8 and 12 on one chart, and columns 9, 10 and 13 on another, we shall have a convenient means of examining the necessity for the hypothesis of eccentric motion. This

OBSERVED VARIATIONS OF LATITUDE AND COMPARISON WITH THEORY, EQ. (58)



will principally be manifest by the large outstanding deviations, on both plots, of the points for Bethlehem, Rockville and San Francisco. Any other values of r_2 and G', computed on a circular hypothesis, which will reconcile these on one chart, will give still greater discordances for them on the other. Indeed it may be remarked that the insufficiency of the hypothesis of a circular annual motion is virtually recognized in the endeavor made by Prof. **Albrecht** to obtain a better representation of the American observations, by altering arbitrarily the coefficient r_2 in eq. (52). Such empirical alterations, if consistently carried out by changing simultaneously r_2 and G', will in effect approximate to the values in columns 4 and 6, which correspond to the elliptic motion.

It is of interest to note that the observations between the middle of 1894 and of 1895, in Europe and on the eastern coast of the United States, will furnish a crucial test of the reality of this elliptical motion. Thus by the chart in no. 329, or the slightly different one drawn by means of the coefficients given in the present article, the variations of latitude near the Berlin meridian, for the first half of this interval, will be almost imperceptible, the latitude remaining a very few hundredths of a second below the normal; while at **Doolittle**'s station and at Columbia College it will increase by a quarter of a second in the same time. For the last half, from January to August 1895, latitudes near Berlin will increase about an eighth of a second, while decreasing at these American stations by nearly double that amount. In general, during the next three or four years, the variations near the Washington meridian will be considerably larger than those in middle Europe. In fact the course of the curve of polar motion in the immediate future will be a series of gradually enlarging elliptical figures, whose longer dimensions will be directed nearly at right angles to those for the past few years, depicted on the chart in no. 329.

NEW ASTEROIDS.

Prof. **Krueger** communicates the discovery of two more small planets by Prof. **Wolf** at Heidelberg.

			h m			h m s		° ′		
BD	12^M	Nov. 1	9 15	Heidelberg M.T.	$\alpha =$	2 26 24,	$\delta =$	+10 12.	Daily motion, -48^s in α,	$-$ 3′ in δ
			2 10 0	" "		2 25 4,		10 8.	" " -72^s	$-$ 2′
BE	11^M	Nov. 1	9 15	" "	$\alpha =$	2 38 48.	$\delta =$	+ 8 8.	Daily motion, -44^s in α	$-15'$ in δ
			2 10 0	" "		2 38 0,		7 33.	" " -48^s	$-32'$

A Paris observation gives the position

Nov. 4 $12^h\ 23^m.4$ Paris M.T. $\alpha = 2^h\ 36^m\ 43^s$, $\delta = +6°\ 30'.6$

thus confirming the large southward motion.

TRANSIT OF *MERCURY*, 1894 NOVEMBER 10.

Prof. C. A. **Young**, of Princeton, N.J., sends the following communication:

The ingress was observed here by myself at the Halsted Observatory, and by Prof. **Reed** at the Observatory of the School of Science. At the Halsted Observatory the instrument was the 23-inch equatorial, full aperture, with a polarizing helioscope and magnifying power of 360. Prof. **Reed** had the 9½-inch equatorial, with a polarizing helioscope and a magnifying power of 155.

Both observers used the sidereal clock of the S. S. Observatory, which is in electrical connection with the Halsted. I took the time from the beats of a magnet actuated by the clock-circuit, an assistant aiding me by giving the minutes and the even ten seconds (10, 20, etc.) in a loud voice. Mr. **Reed** used the chronograph, which explains the fractions of a second in his time-records.

The error of the clock was satisfactorily determined by a set of star-transits the same evening.

The *geodetic* latitude of the S. S. Observatory is 40° 20′ 54″.0 and its *geodetic* longitude is $4^h\ 58^m\ 37^s.1$ west of Greenwich. The Halsted Observatory is 2″ south, and $1^s.98$ west of the other.

At the time of observation it was just clearing up after a storm; the temperature was 42°F., a northwest breeze was blowing, and the sky was full of flying clouds, mostly thin, and with some clear spaces between them. The "seeing" was very bad, so that one could hardly make out the granulations of the solar surface, while the sun's limb was undulating and rather ill defined.

My own observations were as follows, the sidereal clock-times being reduced to Eastern standard times, five hours slow of Greenwich.

At $22^h\ 56^m\ 35^s$ I suspected a sort of "hardening" of the sun's limb close to the expected point of contact, but just at that moment a wisp of cloud blew across, obscuring it for four seconds: as soon as it brightened up at $56^m\ 39^s$ the thing was unmistakable, and at $56^m\ 44^s$ the notch was conspicuous. The advance of the planet surprised me by its rapidity; at $58^m\ 16^s$ a large "black-drop" began to form; at $58^m\ 18^s$ I noted "geometrical contact": and at $58^m\ 22^s$ light broke quiveringly across the dark ligament, and became steady within the next second.

Prof. **Reed**'s observations follow. According to the chronograph-record of the external contact he first saw the "notch" at $22^h\ 56^m\ 46^s.1$, when it had already become obvious; so that he marked the observation as "probably a second late." For the internal contact he noted "Possibly up to geometrical contact," at $58^m\ 20^s.3$; "Certainly up to geometrical contact," at $58^m\ 24^s.9$; and "End of black drop," at $58^m\ 30^s.5$.

At the time of egress the sun was wholly obscured, though about three minutes before, and five minutes after, it shone through the clouds.

While the planet was on the sun the sky was mostly overcast, so that no spectroscopic observations or micrometrical measurements were attempted. No bright spot was seen on the planet's disc, nor any circle of light around it.

As to the peculiar "hardening" of the sun's limb just before the external contact, a phenomenon which I have now observed four times, it may be due to the planet's obscuration of the brightest part of the chromosphere close to the disc of the sun, or to some diffraction effect at the limb of the planet; I cannot doubt its reality.

Obs.	Contact	Phase	Observed	Red. to Cen. of Earth
			h m s	m s
C.A.Y.	I Ext.	First suspected "hardening" of limb,	22 56 35	56 42.6
C.A.Y.	I Ext.	Sure contact,	39	46.6
C.A.Y.	I Ext.	Notch conspicuous,	44	51.6
C.A.Y.	II Int.	Geometrical contact,	22 58 18	58 25.5
C.A.Y.	II Int.	Light broke through black ligament,	22	29.5
			h m s	m s
T.R.	I Ext.	Notch obvious; probably a second late,	22 56 46.1	56 53.6
T.R.	II Int.	Possibly up to geometrical contact,	22 58 20.3	58 27.5
T.R.	II Int.	Certainly up to geometrical contact,	24.9	32.4
T.R.	II Int.	End of black drop,	30.5	38.0

Prof. D. P. Todd, of Amherst, Mass., writes that observations of the contact were prevented there by the weather. There were, however, intervals of clear sky, during which the sun was unobscured for a short time. He says:

"The planet appeared perfectly circular, sharply defined about the limb, unattended by any halo or atmospheric ring, and of the same color as the umbrae of the spots on the sun. No attendant satellite of *Mercury* was seen, nor could any bright spot be discerned upon the planet's dark disk, although intently looked for. Any satellite smaller than 100 miles in diameter would have escaped detection."

Rev. George M. Searle, C.S.P., writes:

"I was so fortunate as to obtain both contacts, — the second one particularly well, — being the only observer at Washington who got it, I believe; clouds preventing elsewhere. My times are

	Eastern Standard Time
	h m s
First external contact,	22 57 2
First internal contact,	58 12
Second internal contact,	4 11 20
Half out,	12 10
Second external contact,	12 55

Position of observatory, latitude 38° 56′ 15″, longitude 77° 0′ 0″. The observation of first external contact was no doubt considerably late; all the others were, I think, good. The estimate of "half out" seems to work well. As I called the moments to the recorder, there was no prejudice as to when they ought to be."

Rev. J. G. Hagen, S.J., at the Georgetown College Observatory, says:

"The instrument used for the observations was the 12-inch refractor, with its full aperture. The focus is 15 feet, and the power employed was 160. The contacts were recorded on the chronograph. The following are the results, in Greenwich mean time:

	h m s	
First contact,	15 56 55.5,	(notch plainly visible).
Second contact,	58 9.1	(geometrical contact).

The third and fourth contacts were lost by clouds."

Dr. Charles Lane Poor communicates the results of observations at the Johns Hopkins Observatory in Baltimore, with the 10-inch equatorial, and 3-inch finder.

The focal length of equatorial is 142 inches, and a power 95 was used, higher ones proving unsatisfactory. The clock-corrections were deduced from observations on nights between Nov. 2 and 15, some within a few hours after egress; the adopted values being $-44^s.48$ for the second contact, and $-44^s.68$ for the third.

The results are (E. St. T. = Greenw. M.T. $-5^h\ 0^m$.)

Contact	Observer	Instrument	Chronograph	Eastern St. Time
			h m s	h m s
II	Jewett,	F	14 12 4.1	10 58 35.1
	Poor,	E	6.1	37.1
III	Poor,	E	19 25 12.1 (*a*)	4 10 51.6
	Clutz,	F	13.0	52.5
	Poor,	E	17.2 (*b*)	56.7
IV	Poor,	E	19 27 10.8	4 12 50.0
	Clutz,	F	12.0	51.2

The letters E and F denote respectively the equatorial and the finder. The first contact was lost. Definition poor, except at second contact. The probable error for second and fourth contacts he estimates as $\pm 10^s$. Observation (*a*) is for the last moment of light between the discs, and (*b*) for perfect contact.

The position of the observatory is $5^h\ 6^m\ 26^s$, $+39°\ 17'\ 48''$.

COMET *e* 1894.

Prof. Lewis Swift telegraphs from Lowe Observatory, Echo Mountain, California, that a comet was discovered there by Edward Swift, on Nov. 20, at $8^h\ 30^m$ p.m., in right-ascension $22^h\ 18^m\ 25^s$, declination $-13°\ 7'$. It had a short tail, was moving slowly east, and was very faint.

ANNOUNCEMENT AS TO TWO TELESCOPIC VARIABLES.

Rev. T. E. Espin of Wolsingham, England, announces "that the variability of two red stars, whose positions (1900) are

$0^h\ 49^m.0\quad +58°\ 1'$ and $1^h\ 49^m.8\quad +58°\ 46'$

has been definitively ascertained."

The first of these is (294) —*Cassiopeae*, in the "unconfirmed" list of Chandler's Second Catalogue. The second, if the position is correctly given, is 11^s following and 4′ north of DM. 58°334. It is also worth noting, that Dunér gives DM. 58°342, $1^h\ 51^m\ 34^s$, $+58°\ 47'$ (1900.0) as a red star of the type III *a*! It is possible that Mr. Espin's star may be identical with one of these objects. — Ed.

CORRIGENDUM.

No. 329, p. 136, Notice, col. 2, line —2, *for* twenty-fourth *put* thirty-fourth.

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Announcement as to Two Telescopic Variables.
Corrigendum.

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THE ORBIT OF *DEIMOS*,

By WALTER S. HARSHMAN, Assistant, American Ephemeris.

The determination of the orbit of this satellite is based upon the Washington observations of 1892, published in this Journal, Vol. XII, page 185, with a correction in Vol. XIII, page 48.

In the series of observations given below, the time has been corrected for aberration. When the difference between the times of observing the position-angle and the distance does not exceed two minutes, the mean of the times is given, and the proper corrections have been applied to the observations, to reduce them to that moment.

Observations.

Washington M.T.				Aberration	p	s
		h	m	m	°	″
1892 July	14	12	44.8	3.4	94.91	72.00
	16	12	9.8	3.4	268.44	. . . .
	16	12	38.4	3.4	. . . .	80.08
	18	12	55.4	3.3	73.74	. . . .
	18	13	11.4	3.3	. . . .	60.20
	19	12	7.5	3.3	102.74	60.04
	23	11	9.5	3.2	86.85	81.76
	31	11	49.8	3.2	283.74	65.66
Aug.	2	11	59.9	3.1	92.66	84.30
	5	12	59.5	3.1	284.33	66.46
	9	11	10.9	3.1	272.07	86.44
	11	10	36.4	3.2	. . . .	78.75
1892 Aug.	11	10	59.9	3.2	84.27	. . . .
	12	10	33.1	3.2	109.63	53.19
	13	9	42.7	3.2	261.63	65.37
	14	10	49.0	3.2	278.05	81.45
	16	10	10.0	3.2	91.12	83.59
	17	11	36.2	3.2	109.26	51.21
	18	9	42.8	3.2	266.41	75.82
	19	10	31.3	3.2	283.47	70.05
	23	9	42.9	3.3	270.46	. . . .
	23	9	52.5	3.3	. . . .	78.08
	28	9	32.2	3.4	275.27	79.89

In this paper I have used the following notation:

P = Position-angle of satellite when in superior conjunction.

U = Angular distance of satellite from node when in superior conjunction.

B = Angle between plane of orbit of satellite and line from observer to planet.

N = Ascending node of orbit of satellite on Equator.

J = Inclination of orbit of satellite to Equator.

u = True angular distance of satellite from node.

u_1 = Value of u in a circular orbit.

u_0 = Value of u_1 at the epoch.

e = Eccentricity of orbit of satellite.

ω = Planetocentric angular distance of pericenter of satellite from node.

a = Angle (in seconds) subtended by semi-axis major of orbit of satellite, as seen at distance unity.

n = Mean motion of satellite.

ρ = Linear distance, Earth to planet.

r = Angle (in seconds) subtended by radius-vector of satellite, as seen at distance ρ.

r_0 = r when ρ is unity.

p = Position-angle of satellite.

s = Angular distance (in seconds) of satellite from planet, as seen from Earth.

α, δ = Right-ascension and declination of planet.

The position-angle and distance of *Deimos* were computed by the following formulas:

$$\cos B \cos U = \cos\delta \cos(\alpha - N)$$
$$\cos B \sin U = \cos\delta \cos J \sin(\alpha - N) + \sin\delta \sin J$$
$$\sin B = \cos\delta \sin J \sin(\alpha - N) - \sin\delta \cos J$$

$$\cos B \sin P = -\sin J \cos(\alpha - N)$$
$$\cos B \cos P = \cos\delta \cos J + \sin\delta \sin J \sin(\alpha - N)$$
$$r_1 = r_0\{1 - \sin r \cos B \cos(u - U)\} \div \rho$$
$$s \sin(p - P) = r_1 \sin(u - U)$$
$$s \cos(p - P) = r_1 \sin B \cos(u - U)$$

Nutation, precession and parallax are neglected. The coordinates of *Mars* were taken from the *American Ephemeris.*

The computation was based on the following approximate circular elements.

CIRCULAR ELEMENTS.

Epoch = 1892 Aug. 7.0 Gr. M.T.
Period = $1^d.262429$
$\log n = 2.4550955$
$a = 32''.354$
$J = 38°\ 4'.7$
$N = 48°\ 14'.8$
$u_0 = 132°.15$

A comparison of the observations with the tabular places gives residuals which are taken in the sense, computed minus observed.

If we calculate the differential equations for correcting the elements, omitting second and higher powers of the eccentricity of the orbit, we shall have the following:

$$\delta s = A\delta J + B\delta N + C\delta u_0 + F\delta a + G\delta\kappa + H\delta h$$

$$\delta p = A'\delta J + B'\delta N + C''\delta u_0 + G'\delta\kappa + H'\delta h$$

$$A = \frac{r_1}{57.3} \cos B \sin u \cos(p - P)$$

$$B = \frac{r_1}{57.3} \cos B \sin p \cos\delta \cos(u - U)$$

$$C = \frac{r_1}{57.3} \cos^2 B \cos(u - U) \sin(p - P)$$

$$F = \frac{s}{r_0}$$

$$G = 2C \sin u_1 - \frac{s}{57.3} \cos u_1$$

$$H = -2C \cos u_1 - \frac{s}{57.3} \sin u_1$$

$$A' = -\cos U \sec B + \frac{r_1^2}{s^2} \sin B \tan B \cos U - \frac{r_1}{s} \cos B \cos(u - U) \sin(p - P) \sin U$$

$$B' = -\sin J \sin U \sec B + \frac{r_1^2}{s^2} \tan B \cos\delta \cos P + \frac{r_1}{s} \cos B \cos(u - U) \sin(p - P) \sin J \cos U$$

$$C'' = \frac{r_1^2}{s_2} \sin B$$

$$G' = 2C' \sin u_1$$

$$H' = -2C'' \cos u_1$$

The following table gives the values of the differential coefficients.

In the last column but one are given the residuals found by substituting the final values of the corrections to the elements in the equations of condition.

In order to completely check the computation, the tabular places were computed from the final elliptic elements, and compared with the observations. The last column below gives these residuals.

The agreement between the two sets of residuals is complete.

EQUATIONS OF CONDITION IN p.

Date	ΔJ	ΔN	Δu_0	κ	h	Δp	Residuals	
1892 July 14	+0.339	+0.338	−0.326	+0.216	+0.615	−0.13	−0.42	−0.43
16	−0.067	+0.370	−0.281	+0.040	−0.560	−0.50	+0.16	+0.14
18	−0.830	+0.176	−0.463	−0.637	+0.672	+1.17	+0.58	+0.56
19	+0.806	+0.196	−0.481	+0.630	+0.728	+0.28	+0.21	+0.19
23	−0.140	+0.377	−0.272	−0.078	+0.539	+0.41	+0.02	+0.01
31	+0.833	+0.220	−0.436	−0.588	−0.643	−0.52	−0.03	−0.04
Aug. 2	+0.172	+0.392	−0.257	+0.090	+0.506	+0.34	+0.02	+0.01
5	+0.833	+0.231	−0.413	−0.560	−0.606	−1.02	−0.57	−0.57
9	+0.061	+0.409	−0.241	−0.030	−0.481	+0.04	+0.54	+0.53
11	−0.449	+0.370	−0.301	−0.250	+0.547	+0.80	+0.34	+0.34
12	+1.193	+0.052	−0.574	+0.948	+0.648	−0.28	−0.04	−0.05
13	−0.811	+0.268	−0.427	+0.544	−0.659	−1.66	−0.54	−0.55
14	+0.383	+0.376	−0.259	−0.195	−0.480	−0.90	−0.48	−0.49
16	−0.008	+0.416	−0.236	−0.004	+0.472	+0.76	+0.42	+0.41
17	+1.230	+0.037	−0.578	+0.972	+0.624	+0.88	+1.16	+1.15
18	−0.475	+0.376	−0.307	+0.263	−0.554	−0.84	−0.05	−0.06
19	+0.739	+0.284	−0.335	−0.429	−0.515	−0.87	−0.50	−0.50
23	−0.198	+0.414	−0.252	+0.098	−0.494	−0.60	−0.01	−0.02
28	+0.086	+0.415	−0.233	−0.041	−0.463	−1.25	−0.77	−0.79

Equations of Condition in s.

Date	ΔJ	ΔN	Δu_0	Δa	κ	h	Δs	Residuals	
1892 July 14	+0.049	+0.456	+0.469	+2.266	−1.518	−0.462	+1.30	+0.84	+0.86
16	+0.008	−0.157	−0.162	+2.441	+1.415	−0.087	−0.99	+0.28	+0.28
18	+0.259	−0.841	−0.879	+1.847	−1.993	+0.451	−0.46	−0.84	−0.84
19	+0.221	+0.837	+0.863	+1.898	−1.940	−0.604	+1.38	+0.40	+0.42
23	+0.007	−0.158	−0.165	+2.547	−1.470	+0.119	+0.63	+0.32	+0.32
31	+0.216	+0.858	+0.906	+2.015	+2.062	+0.570	−0.47	−0.48	−0.48
Aug. 2	+0.010	+0.206	+0.218	+2.614	−1.529	−0.172	+0.27	−0.16	−0.15
5	+0.205	+0.845	+0.901	+2.048	+2.072	+0.537	−0.19	−0.15	−0.15
9	0	+0.017	+0.018	+2.644	+1.492	−0.057	−0.89	+0.25	+0.25
11	+0.050	−0.518	−0.551	+2.434	−1.667	+0.569	0	−0.48	−0.49
12	+0.346	+0.978	+1.056	+1.691	−2.282	−0.404	+1.52	−0.02	0
13	+0.201	−0.888	−0.937	+1.952	+2.044	−0.742	−2.21	+0.62	+0.61
14	+0.041	+0.403	+0.431	+2.494	+1.629	+0.269	−0.77	−0.22	−0.22
16	+0.001	−0.113	−0.121	+2.588	−1.463	+0.230	+0.14	−0.30	−0.30
17	+0.349	+0.965	+1.049	+1.644	−2.266	−0.352	+1.96	+0.36	+0.38
18	+0.082	−0.648	−0.688	+2.245	+1.736	−0.699	−3.19	−0.76	−0.77
19	+0.142	+0.712	+0.770	+2.136	+1.912	+0.411	−0.95	−0.73	−0.72
23	+0.026	−0.407	−0.435	+2.383	+1.508	−0.540	−0.99	+0.99	+0.98
28	−0.001	−0.029	−0.031	+2.131	+1.363	−0.181	−1.23	0	0

Below are given the normal equations, and the values of ΔJ, ΔN, etc. in terms of the absolute quantities in the normal equations, marked A_1, A_2 etc. The coefficients in brackets are logarithms. Since it was necessary to make two approximations, I derived provisional elliptic elements and recomputed the tabular places, thus obtaining a new set of residuals. The columns marked A, A' are the absolute terms in the normal equations in the first and second approximations respectively, the differential coefficients remaining constant. The observations were given equal weight.

Normal Equations.

ΔJ	ΔN	Δu_0	Δa	κ	h	A	A'
+8.1714	+1.2428	− 0.9553	+ 4.2902	+ 0.7433	+0.6064	− 0.4521	+0.0647
+1.2428	+9.3773	+ 6.0739	+ 4.3257	− 2.4902	+0.0502	+ 7.0470	−0.0754
−0.9553	+6.0739	+10.9169	+ 4.6944	− 3.2912	+0.1902	+10.1509	−0.0275
+4.2902	+4.3257	+ 4.6944	+96.0339	+ 4.7238	−2 0621	−13.6756	−0.9455
+0.7433	−2.4902	− 3.2912	+ 4.7238	+64.2035	+2.7315	−33.5055	−0.2783
+0.6064	+0.0502	+ 0.1902	− 2.0621	+ 2.7315	+9.9607	+ 7.9253	+0.2428

$$\Delta J = -[9.13549]A_1 + [8.58809]A_2 - [8.55995]A_3 + [7.80156]A_4 + [6.51850]A_5 + [8.00152]A_6$$
$$\Delta N = +[8.58809]A_1 - [9.25249]A_2 + [9.00724]A_3 + [7.14854]A_4 - [7.33635]A_5 - [7.39987]A_6$$
$$\Delta u_0 = -[8.55995]A_1 + [9.00724]A_2 - [9.19000]A_3 + [7.69619]A_4 - [7.62659]A_5 + [7.83528]A_6$$
$$\Delta a = +[7.80156]A_1 + [7.14854]A_2 + [7.69619]A_3 - [8.04638]A_4 + [7.07455]A_5 - [7.49369]A_6$$
$$\kappa = +[6.51850]A_1 - [7.33635]A_2 - [7.62659]A_3 + [7.07455]A_4 - [8.20871]A_5 + [7.67683]A_6$$
$$h = +[8.00152]A_1 - [7.39987]A_2 + [7.83528]A_3 - [7.49369]A_4 + [7.67683]A_5 - [9.01314]A_6$$

The solution of the normal equations gives:

Corrections to Circular Elements.

$\Delta J = -0^\circ.06632 \pm 0^\circ.1342$
$\Delta N = -0^\circ.20031 \pm 0^\circ.1536$
$\Delta u_0 = -0^\circ.71876 \pm 0^\circ.1429$
$\Delta a = +0''.15178 \pm 0''.0383$
$\kappa = +0^\circ.50963 \pm 0^\circ.0462$
$h = -0^\circ.90896 \pm 0^\circ.1166$

Applying these corrections to the assumed circular elements and correcting the mean motion, we have:

Final Elliptic Elements.

Epoch = 1892 Aug. 7.0 Gr. M.T.
Period = $1^d.262441$
Log n = 2.4550916
$a = 32''.5088 \pm 0''.0383$

$$\left.\begin{aligned} J &= 38^\circ\ 0'.7 \\ N &= 48^\circ\ 2'.8 \end{aligned}\right\}\text{Equator. 1892 Aug. 7.}$$

$u_0 = 131^\circ\ 25'.9$
$e = 0.01819 \pm 0.00177$
$\omega = 299^\circ\ 16'.7 \pm 4^\circ\ 0'.2$

The sum of the squares of the residuals derived from equations of condition is 9.2742, and the number of observations 38, therefore the probable error of a single observation is ±0.363.

By means of the semi-axis major of the orbit of *Deimos* and its periodic time, we now determine the mass of *Mars*:

$$\text{Mass of } Mars = \frac{1}{3051389 \pm 10785}$$

A comparison of these elements with those derived by Prof. HALL, from the observations of 1877, shows an apparent motion of the pericenter of 258° ±6°.5.

ACTION OF THE SUN.

The secular change produced by the action of the sun may be expressed approximately as follows:

$$D_t\omega = \tfrac{3}{4}\, n \left(\frac{\tau}{\tau_0}\right)^2 [1+\cos^2 J]$$

where n = mean motion of satellite

τ = periodic time of satellite

τ_0 = periodic time of planet.

Since $\tau = 1.26\, da$; $\tau_0 = 687\, da$

$D_t\omega$ = 0°.4 per year, or 6° in 15 years.

ACTION OF *Phobos*.

The ratio of the mean motions of the two satellites shows the existence of no long-period term in the disturbance caused by *Phobos*.

The secular variation of the pericenter of *Deimos* resulting from the attraction of *Phobos* may be expressed in powers of the ratio of the mean distances.

$$D_t\omega = m_1\, n \left\{ h_0 - \frac{e_1}{e} h_1 \cos(\omega_1 - \omega) \right\}$$

$$h_0 = [9.8751]\, \alpha_1^2 + [0.1481]\, \alpha_1^4 + [0.3119]\, \alpha_1^6 + \dots$$

$$h_1 = -[9.9720]\, \alpha_1^3 - [0.2150]\, \alpha_1^5 - \dots$$

where m_1 = mass of *Phobos*.

e_1 = eccentricity of *Phobos*.

α_1 = ratio of mean distances of *Phobos* and *Deimos*.

ω_1 = planetocentric angular distance of pericenter of *Phobos* from node.

The proper substitution will give

$$D_t\omega = m_1\, n \left\{ 0.164 - 0.080 \frac{e_1}{e} \cos(\omega_1 - \omega) \right\}$$

If we assume the density of *Phobos* to be equal to that of *Mars*, and its diameter to be seven miles, the maximum value of $D_t\omega$ will not exceed one-hundredth of a degree in 15 years.

An assumption of a diameter of 25 miles, and a density five times that of *Mars*, with a ratio of the eccentricities equal to 10, would produce in 15 years a change in the pericenter of *Deimos* not greater than 2°.

ACTION OF *Mars*.

If we consider the planet *Mars* to be composed of homogeneous spheroidal shells, the following formula will give the relation between the polar compression of the planet and the secular motion of the pericenter of the satellite.

$$D_t\omega = \tfrac{3}{5}\, \frac{r'^2}{a^2}\, n E$$

where r' = equatorial radius of *Mars*.

E = polar compression of *Mars*.

Substituting, we have

$$D_t\omega = 4^\circ.135\, E \text{ per day.}$$

Having shown that the effect of the sun and *Phobos* is quite imperceptible, an assumption of a motion of the pericenter equal to 258° would give the polar compression of *Mars* equal to $\dfrac{1}{88 \pm 2}$.

Washington, D.C.

[NOTE.—This paper is an abstract of a thesis for the degree of Doctor of Philosophy at the Columbian Univerisity, presented in June, 1894.]

TRANSIT OF *MERCURY*, 1894 NOVEMBER 10,

OBSERVATIONS OF THE TRANSIT OF *MERCURY*, 1894 *November* 10.

BY W. W. CAMPBELL.

The following observations of the transit of *Mercury* on Saturday, Nov. 10, 1894, were made with the 36-inch equatorial. The aperture was reduced to eight inches. The ingress was observed with magnifying power 350, and the egress and the measures with power 270. The times are Standard Pacific.

Contact I. $19^h\,57^m\,12^s$. "Just a slight indentation of sun's disc. It does not seem that contact could have been seen 5^s earlier. Seeing too poor to make accurate estimate possible. No ring of light seen around the planet at any time during ingress, though carefully looked for."

Contact II. $19^h\,58^m\,23^s$. "Estimated geometrical contact, seeing very poor."

Contact II. $19^h\,58^m\,39^s$. "First glimpse of light between *Mercury* and sun's limb. Seeing very poor, but the apparent form of planet was clearly pear-shape, the apex pointing towards sun's limb. It was intended to measure distances of *Mercury* from the sun's limb, but the images were too unsteady."

Diameter of Mercury. Thirty-one double-distance measures of the *horizontal* diameter of the planet were obtained. They are

8″.48	8″.49	8″.64	8″.66
.41	.49	.23	.39
.21	.58	.61	.44
.50	.52	.29	.39
.54	.44	.38	.70
.52	.33	.21	.34
.48	.44	.54	.47
.63	.49	.65	

Mean, 8″.468 ± 0″.012.

Correcting this for horizontal refraction and reducing to distance unity, we obtain the diameter of *Mercury* (at distance unity)

$$5''.726 \pm 0''.008.$$

It should be noted that while ordinary planetary diameters, such as those of *Mars* or *Jupiter*, are observed too large, owing to irradiation, aberrations, imperfect seeing, etc., the diameter of *Mercury* in transit is naturally observed too small from the same causes.

Search for Possible Satellite. With apertures 8 and 15 inches and power 350, several unsuccessful searches for a satellite of *Mercury* were made.

Position of Mercury on the sun's disc. Shortly before egress, I obtained eighteen measures of the distance between the centre of the planet and the limb of the sun. Nine were made with the fixed wire tangent to the sun's limb and the movable wire bisecting *Mercury*, and nine with the positions of the wires reversed. The eighteen measures have been combined in pairs to form the nine results below. The distances have been corrected for refraction.

	d h m s	″
Nov.	10 1 4 3	49.50
	4 56	44.48
	5 33	41.11
	6 9	37.97
Nov.	10 1 6 42	34.16
	7 17	31.42
	7 46	28.56
	8 13	26.12
	8 41	23.49

$1^h\,10^m\,16^s.4$ "*Mercury* estimated to be one diameter from third contact."

$1^h\,10^m\,58^s.4$ "*Mercury* estimated to be one-half its diameter from third contact."

Contact III. $1^h\,11^m\,36^s.4$. "Last light vanished between *Mercury* and sun's limb. *Mercury* apparently pear-shape, the apex towards sun's limb."

Contact III. $1^h\,12^m\,3^s.4$. "Estimated geometrical contact."

$1^h\,12^m\,35^s.4$. "Estimated that planet is one-half off. No ring of light seen around the edge of planet at any time, though carefully looked for."

Contact IV. $1^h\,13^m\,11^s.4$. "Last trace of indentation of sun's limb. Seeing much better at egress than at ingress. I tried to see the planet projected on the corona after egress. It was not visible. Probably the dark glass screen used would make it invisible, even if the planet could be seen without the screen."

Mt. Hamilton, 1894 *Nov.* 15.

OBSERVATIONS OF TRANSIT OF *MERCURY*, 1894 NOVEMBER 9, 10.

MADE AT THE DETROIT OBSERVATORY, ANN ARBOR, MICH.

LOCAL MEAN TIME.

A. HALL, JR., Observer.

	h m s	
Nov. 10	3 35 20.	Light all around *Mercury*
	3 36 0.5	Light all around *Mercury*
	3 36 19.	Light all around *Mercury*
	3 36 35.	Third contact
	3 37 11.	Still on sun
	3 37 35.	Still on sun
	3 37 49.	Fourth contact

C. R. GILLIS, Observer.

Nov. 10	3 36 26	Third contact
	3 37 54	Fourth contact

S. D. TOWNLEY, Observer.

	h m s	
Nov. 9	22 27 59	*Mercury* on sun's disk about 1½ diam. from limb
Nov. 10	3 36 25	Third contact
	3 37 40	Surely touching sun's limb
	3 37 47	Fourth contact surely passed

J. MONTGOMERY, Observer.

Nov. 10	3 36 37.5	Third contact

Clearing up cold, after rain and snow. Air unsteady, images poor. Clouds at time of ingress, and clouds drifting across the sun all day. Times of contact uncertain, and fourth contact very poor on account of clouds. Mr. MONTGOMERY observed with a small equatorial belonging to the Ann Arbor High School, mounted about 85 feet north, and 260 feet west of Detroit Observatory.

The instruments used by the different observers were as follows:

A. HALL, Jr., 6.05-inch equatorial, focal length 8 feet 1 inch, mag. power 120.

S. D. TOWNLEY, 12¼-inch equatorial, cut down to 5.5 inches, focal length 16 feet 8¼ inches, mag. power 160.

C. R. GILLIS, finder 12¼-inch equatorial, 2⅜-inch glass, focal length 2 feet 9½ inches, mag. power 20.

J. MONTGOMERY, 4⅛-inch equatorial, focal length 4 feet 9 inches, mag. power 80.

OBSERVATIONS OF TRANSIT OF *MERCURY*, 1894 NOVEMBER 10.

MADE AT YALE UNIVERSITY OBSERVATORY, NEW HAVEN, CONN., NOVEMBER 26, 1894.

Observed by ROBERT BROWN with the Grubb 8-inch equatorial diaphragmed down to 3½ inches and power 59.

Yale Observatory Sidereal Time.

h m s	
19 37 26	*Mercury* about 2 diameters within sun's disc.
19 38 26	*Mercury* about 1 diameter within sun's disc.
19 39 26	Inner contact.
19 41 4	*Mercury* gone.

The two last times correspond to $4^h\,11^m\,4^s.7$ and $4^h\,12^m\,42^s.4$ Eastern Standard Time respectively.

Sun's edge boiling, so that contacts were quite uncertain. I thought I had *Mercury* about 4 seconds before "gone," but it was about like a tooth on the edge of a buzz-saw and easily lost.

Observed by F. L. CHASE with one of the semi-lenses of the heliometer, power 80.

Eastern Standard Time.

h m s	
4 11 17.5	Second internal contact.
4 12 54.0	Second external contact.

The sky was clouded over at first contact; after it cleared, 10 sets of measures of the distance of *Mercury* from the sun's limb were obtained with the heliometer, 4 by W. L. ELKIN and 6 by F. L. CHASE, together with measures of the sun's diameter.

MERIDIAN OBSERVATION OF *MERCURY*, NOVEMBER 10, 1894, AT THE LICK OBSERVATORY.

By R. H. TUCKER, Jr.

During the transit of *Mercury* of November 10, the sun and planet were observed with the meridian circle for difference of right-ascension, and for the position of the latter. The observed place depends upon nadir and mire readings, for level, azimuth, and zenith-point, taken before and after the meridian transit; and upon clock corrections determined from B.J. stars on the nights preceding and following. Two clocks were used to check the rates in the interval.

The observed ΔRA. is, sun minus *Mercury*, $+20^s.63$.

The observed apparent place of *Mercury* is

R.A. $= 15^h\ 3^m\ 33^s.36$; Decl. $= -17°\ 12'\ 39''.4$

Reduction in declination to center of Earth $= +10''.5$.

The ephemeris-place for *Mercury*, from *Am. Eph.*, p. 396, is

R.A. $= 15^h\ 3^m\ 33^s.26$; Decl. $= -17°\ 12'\ 28''.4$

for the longitude of the Observatory $2^h\ 58^m\ 22^s$.

FILAR-MICROMETER MEASURES OF THE FIFTH SATELLITE OF *JUPITER*,

By E. E. BARNARD.

1894 *October* 29.

(Satellite preceding)

Standard Pac. Time h m s	Circle r	From pr. limb ″	From center ″
13 36 42	47.071	29.83	51.58
13 39 32	46.987	30.67	52.42
13 41 27	47.172	28.83	50.58
13 42 57	47.188	28.68	50.43
13 44 47	47.322	27.35	49.10
13 46 57	47.253	28.03	49.78
13 48 17	47.296	27.61	49.36
13 51 12	47.357	27.00	48.75
13 55 19	47.450	26.07	47.82
13 57 17	47.678	23.82	45.57

Coincidence of threads $= 50''.084$.

Though the seeing was fine, the satellite was excessively faint and difficult.

In the reduction of these measures, an apparent semidiameter $22''.05$ has been used; this has been corrected for phase by $-0''.30$ before using. The planet was partially obscured by a piece of smoked mica.

Mt. Hamilton, 1894 *Oct.* 30.

ON A NEW VARIABLE OF SHORT PERIOD.

d Serpentis: $\alpha = 18^h\ 19^m\ 48^s.3$, $\delta = +0°\ 6'.9$ (1855).

By PAUL S. YENDELL.

This is No. 2500 of the Potsdam Photometric *Durchmusterung*. In the note on page 482 of the First Part of this work, attention is called to the marked discordances in the measures of this star, and its possible variability.

I began watching the star 1894 August 5, and from that date to November 4, have observed it about fifty times. These observations indicate a variation of about $0^M.7$, from $5^M.0$ to $5^M.7$, in a period of not far from 8.7 days. The light-curve appears to resemble in character that of β *Lyrae*, but the material at hand is not sufficient to make this certain. I have, however, adopted the principal minimum as the point of departure, and would suggest as provisional elements

1894 August 7.6 (Greenwich M.T.) $+8^d.7\ E$.

The maxima appear to follow the principal minima at $2^d.2$ and $6^d.2$, and a secondary minimum of about $5^M.5$ intervenes at $4^d.3$.

Principal minima have been observed as follows: the comparisons are with the provisional elements above offered.

	w	O—C
1894 Aug. 7.40 Local M.T.	4	0.00
16.36	2	+0.26
Sept. 1.55	1	−0.95
11.37	4	+0.17
20.03	3	+0.13
29.04	2	+0.44
Oct. 6.32	1	−0.98
15.30	3	−0.70
Nov. 2.57	4	+0.17

The comparison-stars used are

	Positions 1855. h m s	 ° ′	Mag.	Light
d = F. 4 *Aquilae*	α = 18 37 31.2	δ = +1 55.1	4.9	18.3
a = F. 74 *Ophiuchi*	18 13 38.2	+3 19.1	5.1	15.3
b = *c Serpentis*	18 22 8.4	−2 4.1	5.5	10.4
c = *e Serpentis*	18 30 9.5	−0 20.1	6.0	5.0

Dorchester, Mass., 1894 *November* 10.

ASTRONOMICAL JOURNAL PRIZES.

Report of the Judges.

The undersigned desire respectfully to recommend that the *Astronomical Journal* Prize, No. I — of $200 to the observer, a resident citizen of the United States, making the best series of determinations of positions of comets between 1893 March 31 and 1894 September 30 (*A.J.* 284 and 305) — be awarded to Prof J. G. Porter, of the Observatory of Cincinnati.

They also have to report that the Prize No. II — of $400 for the best discussion of the path of a periodic comet — calls for no award.

Asaph Hall.
Lewis Boss.
S. C. Chandler.

1894 *November.*

The Prize has accordingly been transmitted to Professor Porter.

FILAR-MICROMETER OBSERVATIONS OF COMET *e* 1894 (E. Swift, *Nov.* 20),

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY.

By E. E. BARNARD.

1894 Mt. Hamilton M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s		m s	′ ″	h m s	° ′ ″		
Nov. 21 7 3 27	1	20 , 7	−1 13.44	−1 45.5	22 20 38.71	−12 50 12.6	9.310	0.830
22 8 0 25	2	12 , 4	+1 12.20	−3 23.6	22 23 45.48	−12 29 3.3	9.346	0.814
23 7 39 35	3	10 , 4	+2 29.94	+6 18.0	22 26 41.05	−12 8 53.7	9.265	0.837

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	22 21 49.35	+2.83	−12 48 39.0	+11.9	Schjellerup 9181
2	22 22 30.27	+3.01	−12 25 51.7	+12.0	Weisse-Bessel XXII, 433
3	22 24 8.12	+2.99	−12 15 23.8	+12.1	Weisse-Bessel XXII, 461

Comet small and very faint; less than 13^{M}. An indefinite brightening near the middle, and a faint trace of a short tail.

MAXIMA AND MINIMA OF LONG-PERIOD VARIABLES,

By J. A. PARKHURST.

107. *T Cassiopeae.*

I have watched this star continuously since July, 1893, and have 34 observations between 1893 Sept. 2, and 1894 Aug. 8. These yield a maximum, $7^{M}.3$, 1894 May 18.

5194. *V Bootis.*

My watch on this star began 1894 Mar. 1, and ended Aug. 18. I have 21 observations, yielding a minimum 1894 Mar. 21, $9^{M}.2$, and a maximum 1894 June 19, $7^{M}.0$. Both dates are somewhat uncertain as I have only two observations before the minimum, and the light curve near the maximum is quite flat.

7085. *RT Cygni.*

I found a steady and rapid rise from about $10^{M}.5$, 1894 Apr. 24, to a maximum of $7^{M}.1$, 1894 June 17, followed by a slower decline to $9^{M}.0$, Aug. 6. I have 25 observations between the above dates.

Marengo, Ill., 1894 *Nov.* 15.

7118. *X Aquilae.*

I have 9 observations, quite evenly distributed between 1894 June 20 and Sept. 1. The star rose steadily from about 10^{M} at the first observation, to a maximum of $8^{M}.6$, 1894 July 30, and then fell at about the same rate to 10^{M} at the last observation.

7783. *RU Cygni.*

From 21 observations between 1894 Jan. 5 and Aug. 9, I deduce a minimum, $9^{M}.2$, 1894 May 19, followed by a steady rise to about 7^{M} at the last observation.

8324. *V Cassiopeae.*

Since the minimum (1894 Mar. 21) published in *A.J.* no. 320, I have 23 observations yielding a well marked maximum, $7^{M}.2$, 1894 July 15. At the last observation, Aug. 20, the star had fallen to 9^{M}.

COMET *e* 1894 (SWIFT).

This comet, discovered by **EDWARD SWIFT** Nov. 20, was observed by **BARNARD** at the Lick Observatory on the three days immediately following. These observations are given in detail in this number, page 151.

The comet was very faint, and estimated by Prof. **BARNARD** as not so bright as a 13^{M} star.

No other observations seem to have been made in the United States with the exception of one made by Father **SEARLE**, at the Catholic University of Washington. He found difficulty in detecting it, his telescope having but nine inches aperture, but obtained the following observation.

1894 Greenwich M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			m s	′ ″	h m s	° ′ ″		
Nov. 28 12 1 18	1	4	+4 26.98	+11 45.9	22 40 55.20	−10 28 47.0	8.919	0.824
12 1 18	2	4	+3 25.84	+10 27.2	22 40 55.49	−10 28 48.3	8.949	0.824

Mean Places for 1894.0 *of Comparison-Stars.*

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	22 36 25.24	+2.98	−10 40 46.2	+13.3	Lalande 44373 (Yarnall)
2	22 37 26.67	+2.98	−10 39 28.8	+13.3	65 *Aquarii* (Newcomb)

The following parabolic elements computed by **LEUSCHNER** from **BARNARD**'s observations were received by telegraph from California, Nov. 29.

$$T = 1894\text{ Oct. }4.90$$
$$\omega = 291°\ 48'$$
$$\Omega = 43\ \ 4$$
$$i = 3\ \ 16$$
$$\log q = 0.1674$$

A finding-ephemeris, derived from these by Father **SEARLE**, was at once distributed among American astronomers by Mr. **RITCHIE**.

Greenwich M.T.	α	δ	Brightn.
	h m s	° ′	
Dec. 2.5	22 53 36	−8 58	0.70
6.5	23 4 20	−7 40	
10.5	23 14 48	−6 23	
14.5	23 25 0	−5 8	0.51

The correction indicated by **SEARLE**'s observation was about $-1^{m}.6$ in α, and $-12'$ in δ.

The indications suggest an orbit belonging to the same group with the comets 1585, 1844 I, 1886 VII, etc.

The positions of Nov. 21, 23, 28 presented the peculiar case that they are in a great circle, and the geocentric angle between sun and comet is not far from 90°. This great circle Father **SEARLE** found to be inclined to the equator by 27° 47′ 40″, having its node at 0° 46′ 33″.

From these observations Dr. **CHANDLER** has determined an approximate parabola for providing a finding-ephemeris.

ELEMENTS.

$$T = 1894\text{ Oct. }25.1111\text{ Greenw. M.T.}$$
$$\left.\begin{aligned}\omega &= 306°\ 23'\ 28''.7\\ \Omega &= 44\ \ 50\ \ 42.9\\ i &= 3\ \ 10\ \ 13.0\end{aligned}\right\}\text{ App. Equin.}$$
$$\log q = 0.18237$$
$$\text{O}-\text{C},\quad \Delta\lambda\cos\beta = +7''.0\ ,\quad \Delta\beta = -4''.8$$

EPHEMERIS FOR GREENWICH MIDNIGHT.

	α	δ	log Δ	Brightn.
	h m s	° ′		
Dec. 14.5	23 26 29	−4 55.7	0.1464	0.61
18.5	37 25	3 33.9	0.1610	0.55
22.5	48 10	2 13.6	0.1754	0.51
26.5	23 58 44	−0 54.7	0.1903	0.46
30.5	0 9 8	+0 22.5	0.2052	0.41

The comet is doubtless of short period, and since its apparition will be brief, observations are much needed.

CORRIGENDUM.

No. 330, p. 141, col. 2, maximum brightness of χ *Cygni*, *for* $4^{M}.9$ *put* $4^{M}.3$.

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ASTRONOMICAL JOURNAL.

No. 332.

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ON PROF. NEWCOMB'S DEVELOPMENT OF THE PERTURBATIVE FUNCTION,

BY A. CHÉSSIN.

In a note in the *Astr. Journal* (No. 326), I have shown how the computation of the operators $\Pi^{m;n}_{m',n'}$ can be dispensed with in the development of the perturbative function in terms of the eccentric anomalies, as given by Prof. SIMON NEWCOMB in his *Astronomical Papers*, Part I, Vol. III. In that note I have considered only the terms of the class 0. I will now extend the method given there to terms of any class, and also give the expression of any term $P^{m;n}_{m',n'}$, $Q^{m,n}_{m',n'}$, $R^{m;n}_{m',n'}$, . . . in function of the terms $P^{m;n}_{m,n}$, $Q^{m,n}_{m,n}$, $R^{m,n}_{m,n}$, . . . in which the upper and lower indices are the same.

I have mentioned already in the note referred to, that *all the symbols $\Pi^{m;n}_{m',n'}$ in which the indices m, m', n and n' differ, can be expressed linearly in function of operators $\Pi^{m,n}_{m,n}$ in which the upper and lower indices are the same.* Let us find this expression. For this purpose we consider first the operators $\Pi^{m}_{m'}$. As the numbers m and m' can only differ by multiples of 2 (see Prof. NEWCOMB's paper), we may give to this operator the general form Π^{n+m}_{n-m}, where both n and m are >0. Now, I will *assume, that* Π^{n+m}_{n-m} *can be expressed linearly in the operators* Π^{n+m}_{n+m}, Π^{n+m-1}_{n+m-1} Π^{n+m-2}_{n+m-2}, ... , Π^{n-m}_{n-m} if $n-m>0$; if $n-m \leqq 0$ this series of operators must end with the operator Π^{0}_{0}.

Thus, let us put

$$\Pi^{n+m}_{n-m} = a^{m,n}_{0}\,\Pi^{n+m}_{n+m} + a^{m,n}_{1}\,\Pi^{n+m-1}_{n+m-1} + a^{m,n}_{2}\,\Pi^{n+m-2}_{n+m-2} + \ldots . \qquad (1)$$

the last coefficient $a^{m,n}_{k}$ being $a^{m;n}_{2m}$ if $n-m \geqq 0$ and $a^{m;n}_{n+m}$, if $n-m<0$; n and m are >0. If we can find expressions for the coefficients $a^{m,n}_{k}$ which satisfy the relation (1), our assumption will be justified.

We have between the operators $\Pi^{m}_{m'}$ the following relation (see formulas (30) in Prof. NEWCOMB's paper):

$$(2) \qquad (n+m)\,\Pi^{n+m}_{n-m} = (\mu - \mathrm{D}) \sum_{e=1}^{n} \Pi^{n-e+m}_{n-e-m} - (\mu + \mathrm{D}) \sum_{e=1}^{m} \Pi^{n+m-e}_{n-m+e} + 2\mathrm{D} \sum_{e=1}^{m} (-1)^{e}\, \Pi^{n+m-2e}_{n-m}$$

In this we make the substitutions:

$$(3) \qquad \sum_{e=1}^{n} \Pi^{n-e+m}_{n-e-m} = \sum_{e=1}^{n} \sum_{k=0}^{2m} a^{m,\,n-e}_{k}\, \Pi^{n+m-k-e}_{n+m-k-e}$$

$$(4) \qquad \sum_{e=1}^{m} \Pi^{n+m-e}_{n-m+e} = \sum_{e=1}^{m} \sum_{k=0}^{2(m-e)} a^{m-e,\,n}_{k}\, \Pi^{n+m-e-k}_{n+m-e-k}$$

$$(5) \qquad \sum_{e=1}^{m} (-1)^{e}\, \Pi^{n+m-2e}_{n-m} = \sum_{e=1}^{m} \sum_{k=0}^{2(m-e)} (-1)^{e}\, a^{m-e,\,n-e}_{k}\, \Pi^{n+m-2e-k}_{n+m-2e-k}$$

which formulas follow from (1). Besides, it must be remembered, that

$$-\mathrm{D}\Pi^{k}_{k} = (k+1)\,\Pi^{k+1}_{k+1} - (\mu+k)\,\Pi^{k}_{k} \qquad (6)$$

(see (31) in Prof NEWCOMB's paper). We shall then find, that

$$(n+m)\,\Pi^{n+m}_{n-m} = \sum_{e=0}^{e=2m} \mathrm{A}^{m,n}_{e}\, \Pi^{n+m-e}_{n+m-e} \quad \text{if} \quad n-m \geqq 0 \qquad (7)$$

$$(n+m)\,\Pi^{n+m}_{n-m} = \sum_{e=0}^{e=n+m} \mathrm{A}^{n,m}_{e}\, \Pi^{n+m-e}_{n+m-e} \quad \text{if} \quad n-m < 0 \qquad (7)'$$

where: 1) when e = even number.

$$(8)_1 \qquad \begin{aligned} \mathrm{A}^{m,n}_{e} = {} & (n+m-e) \left\{ \sum_{k=0}^{e} \left(a^{m,\,n-e-1+k}_{k} + a^{m-e-1+k,\,n}_{k}\right) - 2 \sum_{k=0}^{\frac{e}{2}-1} (-1)^{k+\frac{e}{2}}\, a^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k}_{2k+1} \right\} \\ & + \mu \sum_{k=0}^{e-1} \left(a^{m,\,n-e+k}_{k} - a^{m-e+k,\,n}_{k}\right) \\ & -(\mu+n+m-e) \left\{ \sum_{k=0}^{e-1} \left(a^{m,\,n-e+k}_{k} + a^{m-e+k,\,n}_{k}\right) - 2 \sum_{k=0}^{\frac{e}{2}-1} (-1)^{k+\frac{e}{2}}\, a^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k}_{2k} \right\} \end{aligned}$$

2) when e = odd number.

$$(8)_2 \qquad \mathrm{A}_e^{m,n} = (n+m-e)\left\{\sum_{0}^{e}{}^{k}\left(a_k^{m,\,n-e-1+k} + a_k^{m-e-1+k,\,n}\right) - 2\sum_{0}^{\frac{e-1}{2}}{}^{k}(-1)^{k+\frac{e+1}{2}}\,a_{2k}^{m-\frac{e+1}{2}+k,\,n-\frac{e+1}{2}+k}\right\}$$

$$+\mu \sum_{k=0}^{k=e-1}{}^{k}\left(a_k^{m,\,n-e+k} - a_k^{m-e+k,\,n}\right)$$

$$-(\mu+n+m-e)\left\{\sum_{0}^{e-1}{}^{k}\left(a_k^{m,\,-e+k} + a_k^{m-e+k,\,n}\right) - 2\sum_{0}^{\frac{e-3}{2}}{}^{k}(-1)^{k+\frac{e+1}{2}}\,a_{2k}^{m-\frac{e+1}{2}+k,\,n-\frac{e+1}{2}+k}\right\}$$

It will be more convenient to write these expressions in the following form:

1) $e =$ even number.

$$(9)_1 \qquad \mathrm{A}_e^{m,n} = -2\mu\left\{\sum_{0}^{e-1}{}^{k} a_k^{m-e+k,\,n} - \sum_{0}^{\frac{e}{2}-1}{}^{k}(-1)^{k+\frac{e}{2}}\,a_{2k}^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k}\right\}$$

$$+(n+m-e)\left\{\sum_{0}^{e}{}^{k}\left(a_k^{m,\,n-e-1+k}+a_k^{m-e-1+k,\,n}\right) - \sum_{0}^{e-1}{}^{k}\left(a_k^{m,\,n-e+k}+a_k^{m-e+k,\,n}\right)\right\}$$

$$-2(n+m-e)\sum_{0}^{\frac{e}{2}-1}{}^{k}(-1)^{k+\frac{e}{2}}\left(a_{2k+1}^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k} - a_{2k}^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k}\right)$$

2) $e =$ odd number.

$$(9)_2 \qquad \mathrm{A}_e^{m,n} = -2\mu\left\{\sum_{0}^{e-1}{}^{k} a_k^{m-e+k,\,n} - \sum_{0}^{\frac{e-3}{2}}{}^{k}(-1)^{k+\frac{e-1}{2}}\,a_{2k+1}^{m-\frac{e-1}{2}+k,\,n-\frac{e-1}{2}+k}\right\}$$

$$+(n+m-e)\left\{\sum_{0}^{e}{}^{k}\left(a_k^{m,\,n-e-1+k}+a_k^{m-e-1+k,\,n}\right) - \sum_{0}^{e-1}{}^{k}\left(a_k^{m,\,n-e+k}+a_k^{m-e+k,\,n}\right)\right\}$$

$$-2(n+m-e)\left\{\sum_{0}^{\frac{e-1}{2}}{}^{k}(-1)^{k+\frac{e+1}{2}}\,a_{2k}^{m-\frac{e+1}{2}+k,\,n-\frac{e+1}{2}+k} - \sum_{0}^{\frac{e-3}{2}}{}^{k}(-1)^{k+\frac{e-1}{2}}\,a_{2k+1}^{m-\frac{e-1}{2}+k,\,n-\frac{e-1}{2}+k}\right\}$$

It follows from (1) and (7), (7)′, that

$$(10) \qquad \mathrm{A}_e^{m,n} = (n+m)\,a_e^{m,n}$$

This gives for $e = 0$:

$$\mathrm{A}_0^{m,n} = (n+m)\,a_0^{m,n}$$

But the expression of $\mathrm{A}_0^{m,n}$ is after formula $(9)_1$

$$\mathrm{A}_0^{m,n} = (n+m)\left(a_0^{m,\,n-1}+a_0^{m-1,\,n}\right)$$

Hence

$$(11) \qquad a_0^{m,n} = a_0^{m,\,n-1} + a_0^{m-1,\,n}$$

Substituting successively $n, n-1, n-2, \ldots, 1$ for n; then adding all the formulas obtained by these substitutions, we find

$$(12) \qquad a_0^{m,n} = a_0^{m,0} + \sum_{1}^{n}{}^{e} a_0^{m-1,\,e}$$

This formula is of the type (8), considered in my note (*Astr. Journal*, no. 326.) We have, therefore:

$$(13) \qquad a_0^{m,n} = \sum_{0}^{m}{}^{e}\frac{n(n+1)\ldots(n+e-1)}{e!}\,a_0^{m-e,\,0}$$

But it follows from (11) that

$$a_0^{m,0} = a_0^{m-1,0} = \ldots = a_0^{1,0} = a_0^{0,0} = 1$$

because $a_k^{m,n} = 0$ for all negative values of m and n, by definition. Besides, as can be easily shown,

$$\sum_{0}^{m}{}^{e}\frac{n(n+1)\ldots(n+e-1)}{e!} = \frac{(n+m)!}{n!\;m!}$$

Hence

$$a_0^{m,n} = \frac{(m+n)!}{m!\;n!} \qquad (14)$$

I will now demonstrate the following

Theorem: *If the relation*

$$a_k^{m-1,\,n} + a_k^{m,\,n-1} = a_k^{m,n} + a_{k-2}^{m-1,\,n-1} \qquad (15)$$

holds for $k < e$, *it will hold also for* $k = e$.

To fix the ideas, suppose $e =$ even number. The demonstration can be done in a quite similar way when $e =$ odd number. Then $\mathrm{A}_e^{m,n}$ is given by formula $(9)_1$. Let us form the exprèssion $\mathrm{A}_e^{m,\,n-1} + \mathrm{A}_e^{m-1,\,n}$. By means of $(9)_1$ we find that

$$\mathrm{A}_e^{m-1,\,n} + \mathrm{A}_e^{m,\,n-1} = -2\mu\left\{\sum_{0}^{e-1}{}^{k}\left(a_k^{m-e+k-1,\,n}+a_k^{m-e+k,\,n-1}\right) - \sum_{0}^{\frac{e}{2}-1}{}^{k}(-1)^{k+\frac{e}{2}}\left(a_{2k}^{m-\frac{e}{2}+k-1,\,n-\frac{e}{2}+k} + a^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k-1}\right)\right\}$$

$$+(n+m-e-1)\left\{\sum_{0}^{e}{}^{k}\left[a_k^{m,\,n-e-2+k}+a_k^{m-1,\,n-e-1+k}+a_k^{m-e-2+k,\,n}+a_k^{m-e-1+k,\,n-1}\right] - \sum_{0}^{e-1}{}^{k}\left[a_k^{m,\,n-e+k-1}+a_k^{n-1,\,n-e+k}+a_k^{m-e+k-1,\,n}+a_k^{m-e-+k,\,n-1}\right]\right\}$$

$$-2(n+m-e-1)\sum_{k=0}^{\frac{e}{2}-1}(-1)^{k+\frac{e}{2}}\left[a_{2k+1}^{m-\frac{e}{2}+k-1,\,n-\frac{e}{2}+k}+a_{2k+1}^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k-1}-a_{2k}^{m-\frac{e}{2}+k-1,\,n-\frac{e}{2}+k}-a_{2k}^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k-1}\right] \qquad (16)$$

We now transform this expression by means of formula (15), which we have admitted to be true so long as $k<e$. We can, therefore, apply (15) to all terms in the expression (16), except to those, where $k=e$. This transformation gives

$$\begin{aligned}
A_e^{m-1,\,n}+A_e^{m,\,n-1} = &-2\mu\left\{\sum_{k=0}^{e-1}a_k^{m-e+k,\,n}-\sum_{k=0}^{\frac{e}{2}-1}(-1)^{k+\frac{e}{2}}\,a_{2k}^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k}\right\}\\
&-2\mu\left\{\sum_{k=0}^{e-1}a_{k-2}^{m-e+k-1,\,n-1}-\sum_{k=0}^{\frac{e}{2}-1}(-1)^{k+\frac{e}{2}}\,a_{2(k-1)}^{m-\frac{e}{2}+k-1,\,n-\frac{e}{2}+k-1}\right\} \qquad (16)'\\
&+(n+m-e-1)\left\{\sum_{k=0}^{e-1}\left[a_k^{m,\,n-e+k-1}+a_k^{m-e+k-1,\,n}-a_k^{m,\,n-e+k}-a_k^{m-e+k,\,n}\right]-2\sum_{k=0}^{\frac{e}{2}-1}(-1)^{k+\frac{e}{2}}\left(a_{2k-1}^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k}-a_{2k}^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k}\right)\right\}\\
&+(n+m-e-1)\left\{\sum_{k=0}^{e}\left[a_{k-2}^{m-1,\,n-e+k-2}+a_{k-2}^{m-e+k-2,\,n-1}\right]-\sum_{k=0}^{e-1}\left[a_{k-2}^{m-1,\,n-e+k-1}+a_{k-2}^{m-e+k-1,\,n-1}\right]\right.\\
&\left.-2\sum_{k=0}^{\frac{e}{2}-1}(-1)^{k+\frac{e}{2}}\left[a_{2k-1}^{m-\frac{e}{2}+k,-1\ n-\frac{e}{2}+k-1}-a_{2(k-1)}^{m-\frac{e}{2}+k-1,\,n-\frac{e}{2}+k-1}\right]\right\}+(n+m-e-1)\left(a_e^{m,\,n-1}+a_e^{m-1,\,n}\right)
\end{aligned}$$

the last two terms being those, to which the transformation (15) could not have been applied to. Now, we obviously have:

$$(17)\qquad \sum_{k=0}^{e-1}a_{k-2}^{m-e+k-1,\,n-1}=\sum_{k=0}^{e-3}a_k^{m-e+k+1,\,n-1}$$

$$\sum_{k=0}^{\frac{e}{2}-1}(-1)^{k+\frac{e}{2}}\,a_{2(k-1)}^{m-\frac{e}{2}+k-1,\,n-\frac{e}{2}+k-1}=-\sum_{k=0}^{\frac{e}{2}-2}(-1)^{k+\frac{e}{2}}\,a_{2k}^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k}$$

and so on. By means of formulas (17) and analogous ones the sums containing terms $a_{k-2}^{m',\,n'}$, $a_{2k-1}^{m,\,n'}$, $a_{2(k-1)}^{m',\,n'}$ are transformed into sums containing terms $a_k^{m'',\,n''}$, $a_{2k+1}^{m'',\,n''}$, $a_{2k}^{m''1,\,n''}$. The expression (16)′ then easily reduces to the form:

$$\begin{aligned}
A_e^{m,\,n-1}+A_e^{m-1,\,n}=A_e^{m,\,n}+A_{e-2}^{m-1,\,n-1}-\left(a_e^{m-1,\,n}+a_e^{m,\,n-1}\right)-&\\
-\left\{\begin{aligned}
&\sum_{k=0}^{e-1}\left(a_k^{m,\,n-e-1+k}+a_k^{m-e-1+k,\,n}\right)+\sum_{k=0}^{e-2}\left(a_k^{m-1,\,n-e+k}+a_k^{m-e+k,\,n-1}\right)\\
&-\sum_{k=0}^{e-1}\left(a_k^{m,\,n-e+k}+a_k^{m-e+k,\,n}\right)-\sum_{k=0}^{e-3}\left(a_k^{m-1,\,n-e+k+1}+a_k^{m-e+k+1,\,n-1}\right)\\
&-2\sum_{k=0}^{\frac{e}{2}-1}(-1)^{k+\frac{e}{2}}\left(a_{2k+1}^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k}-a_{2k}^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k}\right)+2\sum_{k=0}^{\frac{e}{2}-2}(-1)^{k+\frac{e}{2}}\left(a_{2k+1}^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k}-a_{2k}^{m-\frac{e}{2}+k,\,n-\frac{e}{2}+k}\right)
\end{aligned}\right\}& \qquad (18)
\end{aligned}$$

By quite similar transformation it is easy to see that the expression in the large brackets in (18) is reduced to the term $-2a_{e-2}^{m-1,\,n-1}$. Hence

$$A_e^{m,\,n-1}+A_e^{m-1,\,n}=A_e^{m,\,n}+A_{e-2}^{m-1,\,n-1}-\left(a_e^{m-1,\,n}+a_e^{m,\,n-1}-2a_{e-2}^{m-1,\,n-1}\right)$$

or, on account of formula (10):

$$\begin{aligned}(m+n-1)\left(a_e^{m,\,n-1}+a_e^{m-1,\,n}\right)=(m+n)&\left(a_e^{m,\,n}+a_{e-2}^{m-1,\,n-1}\right)\\ &-\left(a_e^{m-1,\,n}+a_e^{m,\,n-1}\right)\end{aligned}$$

$$(19)\qquad i.e.\qquad a_e^{m,\,n-1}+a_e^{m-1,\,n}=a_e^{m,\,n}+a_{e-2}^{m-1,\,n-1}\,.$$

q.e.d.

We have seen, that the relation (19) holds for $e=0$ [see (11)]. It follows from the above theorem, that *the relation* (19) *holds for all the values of e.* This result enables us to find the expression of any coefficient $a_k^{m,\,n}$.

We have already found the expression of the coefficient $a_0^{m,\,n}$. Let us find now that of $a_1^{m,\,n}$. It follows from $(9)_2$, that

$$\left.\begin{aligned}A_1^{m,\,n}=(n+m)\,a_1^{m,\,n}=&-2\mu\,a_0^{m-1,\,n}\\ &+(n+m-1)\left(a_1^{m,\,n-1}+a_1^{m-1,\,n}\right)\end{aligned}\right\}\qquad (20)$$

By the above theorem $a_1^{m,\,n-1}+a_1^{m-1,\,n}=a_1^{m,\,n}$. Hence

$$a_1^{m,\,n}=-2\mu\,a_0^{m-1,\,n} \qquad (21)$$

If we proceed in like manner in the general case, we shall find the general expression for $a_k^{m,\,n}$:

$$a_k^{m,\,n}=\sum_{e=0}^{e_1}\varphi_{k,\,e}^{(m+n)}\,\theta_{k-2e}\,a_0^{m-k+e,\,n-e} \qquad (22)$$

$$e_1\leqq\frac{k}{2} \qquad (23)$$

where (24)

$$\varphi_{k,\,e}^{(m+n)}=\frac{(-1)^e(\mu+n+m-k)(\mu+n+m-k+1)\ldots(\mu+n+m-k+e-1)}{e\,!}$$

$$\theta_s=(-1)^s\,\frac{2\mu(2\mu-1)\ldots.(2\mu-s+1)}{s\,!} \qquad (25)$$

The upper limit of the summation e_1 is given in every case by the condition, that *none of the indices* $(k-2e)$, $(m-k+e)$, $(n-e)$ *be negative.* We shall therefore have

$$(26)\qquad \Pi^{n+m}_{n-m} = \sum_{0}^{k_1} {}_k\, a^{m,n}_{k}\, \Pi^{n+m-k}_{n+m-k} = \sum_{0}^{k_1} {}_k \sum_{0}^{e_1} {}_e\, \varphi^{(m+n)}_{k,e}\, \theta_{k-2e}\, a^{m-k+e,\,n-e}_{0}\, \Pi^{n+m-k}_{n+m-k}$$

$$(27)\qquad \left\{\begin{array}{lll} k_1 = n+m & \text{if} & n-m<0 \\ k_1 = 2m & \text{if} & n-m \leqq 0 \end{array}\right\}$$

The definition of the symbols $\Pi^{m;\,n}_{m',n'}$ then leads at once to the formulas:

$$(28)\qquad \Pi^{n+m,\,s}_{n-m,\,t} = \sum_{0}^{k_1} {}_k \sum_{0}^{e_1} {}_e\, \varphi^{(m+n)}_{k,e}\, \theta_{k-2e}\, a^{m-k+e,\,n-e}_{0}\, \Pi^{n+m-k,\,s}_{n+m-k,\,t}$$

$$(29)\qquad \Pi^{s,\,n+m}_{t,\,n-m} = \sum_{0}^{k_1} {}_k \sum_{0}^{e_1} {}_e\, \varphi'^{(m+n)}_{k,e}\, \theta'_{k-2e}\, a^{m-k+e,\,n-e}_{0}\, \Pi^{s,\,n+m-k}_{t,\,n+m-k}$$

where $\varphi'^{(m+n)}_{k,e}$, θ'_{k-2e} are given by the formulas (24), (25) in which ν is substituted for μ.

It remains only to apply these operators on A_i, B_i, C_i, ... For the terms of the class 0 we must substitute $-i$ for μ, and $+i$ for ν. For those of the class 1 substitute $1-i$ for μ, and $1+i$ for ν. For those of the class 2, $2-i$ for μ, and $2+i$ for ν.; and so on. Let us write $\varphi^{(m+n)}_{k,e,0}$, $\theta_{e,0}$ for $\varphi^{(m+n)}_{k,e}$, θ_e, in the first case; $\varphi^{(m+n)}_{k,e,1}$, $\theta_{e,1}$ in the second; $\varphi^{(m+n)}_{k,e,2}$, $\theta_{e,2}$ in the third; and so on. Then (28) and (29) applied on A_i, B_i, C_i, ... will give

$$(30)_1\qquad \underset{(i)}{\mathrm{P}}{}^{n+m,\,s}_{n-m,\,t} = \sum_{0}^{k_1} {}_k \sum_{0}^{e_1} {}_e\, \varphi^{(m+n)}_{k,e,0}\, \theta_{k-2e,0}\, a^{m-k+e,\,n-e}_{0}\, \underset{(i)}{\mathrm{P}}{}^{n+m-k,\,s}_{n+m-k,\,t}$$

$$(30)_2\qquad \underset{(i)}{\mathrm{Q}}{}^{n+m,\,s}_{n-m,\,t} = \sum_{0}^{k_1} {}_k \sum_{0}^{e_1} {}_e\, \varphi^{(m+n)}_{k,e,1}\, \theta_{k-2e,1}\, a^{m-k+e,\,n-e}_{0}\, \underset{(i)}{\mathrm{Q}}{}^{n+m-k,\,s}_{n+m-k,\,t}$$

$$(30)_3\qquad \underset{(i)}{\mathrm{R}}{}^{n+m,\,s}_{n-m,\,t} = \sum_{0}^{k_1} {}_k \sum_{0}^{e_1} {}_e\, \varphi^{(m+n)}_{k,e,2}\, \theta_{k-2e,2}\, a^{m-k+e,\,n-e}_{0}\, \underset{(i)}{\mathrm{R}}{}^{n+m-k,\,s}_{n+m-k,\,t}$$

and so on.

$$(31)_1\qquad \underset{(i)}{\mathrm{P}}{}^{s,\,n+m}_{t,\,n-m} = \sum_{0}^{k_1} {}_k \sum_{0}^{e_1} {}_e\, \varphi'^{(m+n)}_{k,e,0}\, \theta'_{k-2e,0}\, a^{m-k+e,\,n-e}_{0}\, \underset{(i)}{\mathrm{P}}{}^{s,\,n+m-k}_{t,\,n+m-k}$$

$$(31)_2\qquad \underset{(i)}{\mathrm{Q}}{}^{s,\,n+m}_{t,\,n-m} = \sum_{0}^{k_1} {}_k \sum_{0}^{e_1} {}_e\, \varphi'^{(m+n)}_{k,e,1}\, \theta'_{k-2e,1}\, a^{m-k+e,\,n-e}_{0}\, \underset{(i)}{\mathrm{Q}}{}^{s,\,n+m-k}_{t,\,n+m-k}$$

and so on. The two sets of formulas (30) and (31) give the solution of our problem. They may be combined in one general one, such that the development on the right will contain only terms $\mathrm{P}^{n,s}_{n,s}$, *both* upper indices being the same as the corresponding lower ones, but this would only make the formulas unnecessarily more complicated. The set of formulas (30) reduces the computation of coefficients $\mathrm{P}^{m,n}_{m',n'}$, $\mathrm{Q}^{m,n}_{m',n'}$, ... to the computation of coefficients $\mathrm{P}^{m,n}_{m,n'}$, $\mathrm{Q}^{m,n}_{m,n'}$, ... in which the *first* upper and lower indices are the same. Then, by means of the set of formulas (31), in which we only need to make $s=t$, we reduce the computation of the coefficients $\mathrm{P}^{m,n}_{m,n'}$, $\mathrm{Q}^{m,n}_{m\,n'}$, ... to the computation of those in which *both* upper and lower indices are the same.

I will now write down those of the formulas which are of the most frequent use. Such are (30) and (31) in which $s=t$ and $m=1$ and 2.

Suppose first $m=1$ and $n \geqq 1$. Then $k_1=2$. Formulas (22–25) give in this case:

$$(*)\qquad a^{1,n}_{0} = n+1\ ;\quad a^{1,n}_{1} = -2\mu\ ;\quad a^{1,n}_{2} = -(\mu+n-1)$$

We have, therefore,

$$\underset{(i)}{\mathrm{P}}{}^{n+1,\,s}_{n-1,\,s} = (n+1)\, \underset{(i)}{\mathrm{P}}{}^{n+1,\,s}_{n+1,\,s} + 2i\, \underset{(i)}{\mathrm{P}}{}^{n,\,s}_{n,\,s} + (i-n+1)\, \underset{(i)}{\mathrm{P}}{}^{n-1,\,s}_{n-1,\,s} \qquad (32)_1$$

$$\underset{(i)}{\mathrm{Q}}{}^{n+1,\,s}_{n-1,\,s} = (n+1)\, \underset{(i)}{\mathrm{Q}}{}^{n+1,\,s}_{n+1,\,s} + 2(i-1)\, \underset{(i)}{\mathrm{Q}}{}^{n,\,s}_{n,\,s} + (i-n)\, \underset{(i)}{\mathrm{Q}}{}^{n-1,\,s}_{n-1,\,s} \qquad (32)_2$$

$$\underset{(i)}{\mathrm{R}}{}^{n+1,\,s}_{n-1,\,s} = (n+1)\, \underset{(i)}{\mathrm{R}}{}^{n+1,\,s}_{n+1,\,s} + 2(i-2)\, \underset{(i)}{\mathrm{R}}{}^{n,\,s}_{n,\,s} + (i-n-1)\, \underset{(i)}{\mathrm{R}}{}^{n-1,\,s}_{n-1,\,s} \qquad (32)_3$$

and so on.

Suppose now $m=1$ but $n=0$. Then $k_1=m=1$, and instead of the above formulas, we shall have

$$\underset{(i)}{\mathrm{P}}{}^{1,\,s}_{-1,\,s} = \underset{(i)}{\mathrm{P}}{}^{1,\,s}_{1,\,s} + 2i\, \underset{(i)}{\mathrm{P}}{}^{0,\,s}_{0,\,s} \qquad (32)_1'$$

$$\underset{(i)}{\mathrm{Q}}{}^{1,\,s}_{-1,\,s} = \underset{(i)}{\mathrm{Q}}{}^{1,\,s}_{1,\,s} + 2(i-1)\, \underset{(i)}{\mathrm{Q}}{}^{0,\,s}_{0,\,s} \qquad (32)_2'$$

$$\underset{(i)}{\mathrm{R}}{}^{1,\,s}_{-1,\,s} = \underset{(i)}{\mathrm{R}}{}^{1,\,s}_{1,\,s} + 2(i-2)\, \underset{(i)}{\mathrm{R}}{}^{0,\,s}_{0,\,s} \qquad (32)_3'$$

In order to get the other set we must substitute ν for μ in formula (*), then the coefficients $a^{m,n}_{k}$ will be

$$(**)\qquad a^{1,n}_{0} = n+1\ ;\quad a^{1,n}_{1} = -2\nu\ ;\quad a^{1,n}_{2} = -(\nu+n-1)$$

If again $n \geqq 1$, we shall have

$$\underset{(i)}{\mathrm{P}}{}^{t,\,n+1}_{t,\,n-1} = (n+1)\, \underset{(i)}{\mathrm{P}}{}^{t,\,n+1}_{t,\,n+1} - 2i\, \underset{(i)}{\mathrm{P}}{}^{t,\,n}_{t,\,n} - (i+n-1)\, \underset{(i)}{\mathrm{P}}{}^{t,\,n-1}_{t,\,n-1} \qquad (33)_1$$

$$\underset{(i)}{\mathrm{Q}}{}^{t,\,n+1}_{t,\,n-1} = (n+1)\, \underset{(i)}{\mathrm{Q}}{}^{t,\,n+1}_{t,\,n+1} - 2(i+1)\, \underset{(i)}{\mathrm{Q}}{}^{t,\,n}_{t,\,n} - (i+n)\, \underset{(i)}{\mathrm{Q}}{}^{t,\,n-1}_{t,\,n-1} \qquad (33)_2$$

$$\underset{(i)}{\mathrm{R}}{}^{t,\,n+1}_{t,\,n-1} = (n+1)\, \underset{(i)}{\mathrm{R}}{}^{t,\,n+1}_{t,\,n+1} - 2(i+2)\, \underset{(i)}{\mathrm{R}}{}^{t,\,n}_{t,\,n} - (i+n+1)\, \underset{(t)}{\mathrm{R}}{}^{t,\,n-1}_{t,\,n-1} \qquad (33)_3$$

and if $n=0$,

$$\underset{(i)}{\mathrm{P}}{}^{t,\,1}_{t,\,-1} = \underset{(i)}{\mathrm{P}}{}^{t,\,1}_{t,\,1} - 2i\, \underset{(i)}{\mathrm{P}}{}^{t,\,0}_{t,\,0} \qquad (33)_1'$$

$$\underset{(i)}{\mathrm{Q}}{}^{t,\,1}_{t,\,-1} = \underset{(i)}{\mathrm{Q}}{}^{t,\,1}_{t,\,1} - 2(i+1)\, \mathrm{Q}^{t,\,0}_{t,\,0} \qquad (33)_2'$$

$$\underset{(i)}{\mathrm{R}}{}^{t,\,1}_{t,\,-1} = \underset{(i)}{\mathrm{R}}{}^{t,\,1}_{t,\,1} - 2(i+2)\, \underset{(i)}{\mathrm{R}}{}^{t,\,0}_{t,\,0} \qquad (33)_3'$$

Let now $m=2$; $n \geqq 2$. Then $k_1=4$, and formulas (22–25) give in this case:

$$\left.\begin{array}{l} a^{2,n}_{0} = \dfrac{(n+2)(n+1)}{1\,.\,2}\ ;\quad a^{2,n}_{1} = -2(n+1)\mu\ ; \\ \qquad\qquad a^{2,n}_{2} = 2\mu^2-(n+1)\mu-n^2 \\ a^{2,n}_{3} = 2\mu(\mu+n-1)\ ;\quad a^{2,n}_{4} = \dfrac{(\mu+n-1)(\mu+n-2)}{1\,.\,2} \end{array}\right\}(***)$$

We have therefore

$$\underset{(i)}{\mathrm{P}}{}^{n+2,\,s}_{n-2,\,s} = \frac{(n+2)(n+1)}{2}\, \underset{(i)}{\mathrm{P}}{}^{n+2,\,s}_{n+2,\,s} + 2i(n+1)\, \underset{(i)}{\mathrm{P}}{}^{n+1,\,s}_{n+1,\,s} \qquad (34)_1$$
$$+ \left[2i^2+(n+1)i-n^2\right] \underset{(i)}{\mathrm{P}}{}^{n,\,s}_{n,\,s}$$
$$+ 2i(i-n+1)\, \underset{(i)}{\mathrm{P}}{}^{n-1,\,s}_{n-1,\,s} + \frac{(i-n+1)(i-n+2)}{2}\, \underset{(i)}{\mathrm{P}}{}^{n-2,\,s}_{n-2,\,s}$$

and analogous expressions for $\mathrm{Q}^{n+2,\,s}_{n-2,\,s}$, $\mathrm{R}^{n+2,\,s}_{n-2,\,s}$, ..., which are obtained by substituting $1-i$, $2-i$ for μ in (***). If $n<2$ we have the same formulas (34), only without the last term (if $n=1$) or without the two last terms (if $n=0$). For the other set of formulas, we must again substitute ν for μ in (***), and we then obtain

$$(35)_1 \quad \underset{(i)}{\mathrm{P}^{t,\,n+2}_{t,\,n-2}} = \frac{(n+2)(n+1)}{2}\underset{(i)}{\mathrm{P}^{t,\,n+2}_{t,\,n+2}} - 2i(n+1)\underset{(i)}{\mathrm{P}^{t,\,n+1}_{t,\,n+1}} + [2i^2-(n+1)i-n^2]\underset{(i)}{\mathrm{P}^{t,\,n}_{t,\,n}} + 2i(i+n-1)\underset{(i)}{\mathrm{P}^{t,\,n-1}_{t,\,n-1}} + \frac{(i+n-1)(i+n-2)}{2}\underset{(i)}{\mathrm{P}^{t,\,n-2}_{t,\,n-2}}$$

and analogous formulas for $\mathrm{Q}^{t,\,n+2}_{t,\,n-2}$, $\mathrm{R}^{t,\,n+2}_{t,\,n-2}$, ... , which are obtained by substituting $1+i$, $2+i$ . . . . , for r. Again, if $n=1$, the last term in (35) is to be made zero; if $n=0$, the two last terms must be made zero.

From the above formulas can be deduced the expressions for $\mathrm{P}^{n+1,\,m+1}_{n-1,\,m-1}$, $\mathrm{Q}^{n+1,\,m+1}_{n-1,\,m-1}$, ... ; $\mathrm{P}^{n+2,\,m+1}_{n-2,\,m-1}$, $\mathrm{Q}^{n+2,\,m+1}_{n-2,\,m-1}$, ... ; $\mathrm{P}^{n+2,\,m+2}_{n-2,\,m-2}$, $\mathrm{Q}^{n+2,\,m+2}_{n-2,\,m-2}$, ... ; and so on. But it would take us too far to give all these here. I will only give one, namely $\mathrm{P}^{n+1,\,m+1}_{n-1,\,m-1}$, as an example. We have seen, that

$$\underset{(i)}{\mathrm{P}^{n+1,\,m+1}_{n-1,\,m-1}} = (n+1)\underset{(i)}{\mathrm{P}^{n+1,\,m+1}_{n+1,\,m-1}} + 2i\underset{(i)}{\mathrm{P}^{n,\,m+1}_{n,\,m-1}} + (i-n+1)\underset{(i)}{\mathrm{P}^{n-1,\,m+1}_{n-1,\,m-1}} \tag{36}$$

If we substitute in (36) the expressions for $\mathrm{P}^{n+1,\,m+1}_{n+1,\,m-1}$, $\mathrm{P}^{n,\,m+1}_{n,\,m-1}$, $\mathrm{P}^{n-1,\,m+1}_{n-1,\,m-1}$, given by formulas (33), we find that

$$(37) \quad \begin{aligned} \underset{(i)}{\mathrm{P}^{n+1,\,m+1}_{n-1,\,m-1}} = {} & (n+1)(m+1)\underset{(i)}{\mathrm{P}^{n+1,\,m+1}_{n+1,\,m+1}} - 2i[(n+1)\underset{(i)}{\mathrm{P}^{n+1,\,m}_{n+1,\,m}} - (m+1)\underset{(i)}{\mathrm{P}^{n,\,m+1}_{n,\,m+1}}] \\ & -4i^2\underset{(i)}{\mathrm{P}^{n,\,m}_{n,\,m}} - [(n+1)(i+m-1)\underset{(i)}{\mathrm{P}^{n+1,\,m-1}_{n+1,\,m-1}} - (m+1)(i-n+1)\underset{(i)}{\mathrm{P}^{n-1,\,m+1}_{n-1,\,m+1}}] \\ & -2i[(i+m-1)\underset{(i)}{\mathrm{P}^{n,\,m-1}_{n,\,m-1}} + (i-n+1)\underset{(i)}{\mathrm{P}^{n-1,\,m}_{n-1,\,m}}] - (i-n+1)(i+m-1)\underset{(i)}{\mathrm{P}^{n-1,\,m-1}_{n-1,\,m-1}} \end{aligned}$$

Since we have thus established the fact that the computation of the different coefficients is reduced to the computation of those only for which both the upper and lower indices are the same, we can restrict ourselves to the forms $\mathrm{P}^{m,\,n}_{m,\,n}$, $\mathrm{Q}^{m,\,n}_{m,\,n}$, $\mathrm{R}^{m,\,n}_{m,\,n}$, ... I have given a method for the computation of the coefficients $\mathrm{P}^{m,\,n}_{m,\,n}$ in no. 326 of this Journal. I have shown, that

$$(38) \qquad \underset{(i)}{\mathrm{P}^{m,\,n}_{m,\,n}} = (-1)^m\frac{(m+n)!}{m!\,n!}\mathrm{P}^{(m+n)}_{i,\,\lambda}$$

where the functions $\mathrm{P}^{(m+n)}_{i,\,\lambda}$ have a remarkable property, namely, they are connected with each other by the relation

$$(39) \qquad \mathrm{P}^{(m+n)}_{i,\,\lambda+1} = \mathrm{P}^{(m+n)}_{i,\,\lambda} + \mathrm{P}^{(m+n-1)}_{i,\,\lambda+1}$$

which enables us to pass from one set of coefficients

$$\ldots.\ \underset{(i-2)}{\mathrm{P}^{m-2,\,n+2}_{m-2,\,n+2}},\ \underset{(i-1)}{\mathrm{P}^{m-1,\,n+1}_{m-1,\,n+1}},\ \underset{(i)}{\mathrm{P}^{m,\,n}_{m,\,n}},\ \underset{(i+1)}{\mathrm{P}^{m+1,\,n-1}_{m+1,\,n-1}},\ \underset{(i+2)}{\mathrm{P}^{m+2,\,n-2}_{m+2,\,n-2}},\ \ldots.$$

to another one

$$\ldots.\ \underset{(i-1)}{\mathrm{P}^{m-2,\,n+2}_{m-2,\,n+2}},\ \underset{(i)}{\mathrm{P}^{m-1,\,n+1}_{m-1,\,n+1}},\ \underset{(i+1)}{\mathrm{P}^{m,\,n}_{m,\,n}},\ \underset{(i+2)}{\mathrm{P}^{m+1,\,n-1}_{m+1,\,n-1}},\ \underset{(i+3)}{\mathrm{P}^{m+2,\,n-2}_{m-2,\,n-2}}\ \ldots.$$

by a simple addition. I will now extend this method to the terms of any class.

I consider next the terms of the class I, *i.e.* the $\underset{(i)}{\mathrm{Q}^{m,\,n}_{m,\,n}}$.

I have already remarked that

$$\sum_0^m{}^e \frac{(n+1)\ldots.(n+e-1)}{e!} = \frac{(n+m)!}{n!\,m!} = \frac{(n+1)(n+2)\ldots(n+m)}{m!} \tag{40}$$

If we substitute $-(i+\mathrm{D})$ for n in this formula, it becomes

$$\sum_0^m{}^e (-1)^e\frac{(i+\mathrm{D})(i+\mathrm{D}-1)\ldots(i+\mathrm{D}-e+1)}{e!} = \frac{(-1)^m(i+\mathrm{D}-1)(i+\mathrm{D}-2)\ldots(i+\mathrm{D}-m)}{m!}$$

$$(41) \quad \text{or} \quad \sum_0^m{}^e \underset{(i)}{\Pi^e_e} = \underset{(i-1)}{\Pi^m_m} \quad (\text{see } \textit{Astr. Jour.}\ \text{p. 105})$$

But $\underset{(i-1)}{\Pi^m_m}$ is nothing else than $\underset{(i)}{\Pi'^m_m}$, because Π'^m_m is obtained by substituting $1-i$ for μ, whereas Π^m_m is obtained by the substitution $-i$ for μ. Hence

$$(41)' \qquad \underset{(i)}{\Pi'^m_m} = \sum_0^m{}^e \underset{(i)}{\Pi^e_e}$$

Then, by definition

$$(41)'' \qquad \underset{(i)}{\Pi'^{0,\,n}_{0,\,n}} = \sum_0^n{}^k \underset{(i)}{\Pi^{0,\,k}_{0,\,k}}$$

and, finally,

$$(42) \qquad \underset{(i)}{\Pi'^{m,\,n}_{m,\,n}} = \sum_0^m{}^e \sum_0^n{}^k \underset{(i)}{\Pi^{e,\,k}_{e,\,k}}$$

Let us now apply this formula on the letter B_i, and denote by $\underset{(i)}{\mathrm{P}'^{m,\,n}_{m,\,n}}$ the result of the operation of $\underset{(i)}{\Pi^{m,\,n}_{m,\,n}}$ on B_i, *i.e.*, let

$$(43) \qquad \underset{(i)}{\mathrm{P}'^{m,\,n}_{m,\,n}} = \underset{(i)}{\Pi^{m,\,n}_{m,\,n}}\mathrm{B}_i$$

Then formula (42) gives

$$(44) \qquad \underset{(i)}{\mathrm{Q}^{m,\,n}_{m,\,n}} = \sum_0^m{}^e \sum_0^n{}^k \underset{(i)}{\mathrm{P}'^{e,\,k}_{e,\,k}}$$

The computation of the $\underset{(i)}{\mathrm{Q}^{m,\,n}_{m,\,n}}$ is therefore reduced to that of the coefficients $\mathrm{P}'^{e,\,k}_{e,\,k}$. These last ones differ from the $\mathrm{P}^{e,\,k}_{e,\,k}$ only on the letter on which the operation is performed; they can, therefore be computed by the rules given in the note on p. 105–107 of this Journal. The computation will be carried out thus:

Let us put

$$\left.\begin{aligned} p'^{(\mu)}_i &= \pi^{(\mu)}_0\,\mathrm{B}_i \\ \mathrm{P}'^{(\mu)}_{i,\,\lambda} &= \pi^{(\mu)}_\lambda\,\mathrm{B}_i \end{aligned}\right\} \tag{45}$$

Then we shall have*

$$\mathrm{P}'^{(m+n)}_{i,\,\lambda} = \sum_0^{m+n}{}^e \alpha^{(\lambda)}_e\, p'^{(m+n-e)}_i \tag{46}$$

$$\underset{(i)}{\mathrm{P}'^{m,\,n}_{m,\,n}} = (-1)^m\frac{(m+n)!}{m!\,n!}\mathrm{P}'^{(m+n)}_{i,\,\lambda} \tag{47}$$

Now, it is obvious that if we perform on the Π'^m_m and $\Pi'^{0,\,n}_{0,\,n}$ the same operations, as we did before on the Π^m_m and $\Pi^{0,\,n}_{0,\,n}$, we will find the rules for the computation of the $\mathrm{R}^{m,\,n}_{m,\,n}$. In fact, we shall find again, that

$$\underset{(i)}{\Pi''^m_m} = \sum_0^m{}^e \underset{(i)}{\Pi'^e_e} \tag{48}$$

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* It was not necessary to make the distinction between $\lambda>0$ and $\lambda<0$. In fact, as it is easy to see,

$$\beta^{(-\lambda)}_e = (-1)^e\alpha^{(\lambda)}_e$$

and formula (46) will be true, whether λ is >0 or <0.

(48′) $$\underset{(i)}{\Pi''}{}^{0,n}_{0,n} = \sum_0^n{}_k\, \underset{(i)}{\Pi'}{}^{0,k}_{0,k}$$

(49) $$\underset{(i)}{\Pi''}{}^{m,n}_{m,n} = \sum_0^m{}_e \sum_0^n{}_k\, \underset{(i)}{\Pi'}{}^{e,k}_{e,k}$$

And if we put

(50) $$\underset{(i)}{\mathrm{P}''}{}^{m,n}_{m,n} = \underset{(i)}{\Pi}{}^{m,n}_{m,n}\, \mathrm{C}_i$$

(51) $$\underset{(i)}{\mathrm{Q}'}{}^{m,n}_{m,n} = \sum_0^m{}_k \sum_0^n{}_e\, \underset{(i)}{\mathrm{P}''}{}^{k,e}_{k,e}$$

we shall have

(52) $$\underset{(i)}{\mathrm{R}}{}^{m,n}_{m,n} = \sum_0^m{}_e \sum_0^n{}_k\, \underset{(i)}{\mathrm{Q}'}{}^{e,k}_{e,k}$$

Again, the computation of the $\mathrm{R}^{m,n}_{m,n}$ is reduced to that of the $\mathrm{P}''^{m,n}_{m,n}$, which differ from the $\mathrm{P}^{m,n}_{m,n}$ only by the letter on which the operation is performed, and can therefore be computed by the same rules, as explained above, *i.e.*. we put

(53) $$\begin{cases} p''^{(\mu)}_i = \pi^{(\mu)}_0\, \mathrm{C}_i \\ \mathrm{P}''^{(\mu)}_{i,\lambda} = \pi^{(\mu)}_\lambda\, \mathrm{C}_i \end{cases}$$

Then we have again:

$$\mathrm{P}''^{(m+n)}_{i,\lambda} = \sum_0^{m+n}{}_e\, \alpha^{(\lambda)}_e\, p''^{(m+n)}_i$$

(55) $$\underset{(i)}{\mathrm{P}''}{}^{m,n}_{m,n} = (-1)^m \frac{(m+n)!}{m!\,n!}\, \mathrm{P}''^{(m+n)}_{i,\lambda}$$

The above process can be extended in the same way to any class.

I will now resume the developments given in this paper, and in my previous note, and indicate the way in which the computation should be made.

1. First are computed the coefficients A_i, B_i, C_i, ... (See, for instance. NEWCOMB's Astronomical Papers.)

2. Then compute the coefficients $p^{(1)}_i$, $p^{(2)}_i$, $p^{(3)}_i$, ... as far as necessary; also the $p'^{(1)}_i$, $p'^{(2)}_i$, $p'^{(3)}_i$, ...; $p''^{(1)}_i$, $p''^{(2)}_i$, $p''^{(3)}_i$, ...; and so on. It is advisable to write them in a tabular form.

3. The $\mathrm{P}^{(m+n)}_{i,\lambda}$ are now computed. We begin with $\mathrm{P}^{(1)}_{i,\lambda}$, which we compute for any *one* value of λ.* Then the $\mathrm{P}^{(1)}_{i,\lambda}$ for other values of λ will be given by the formulas:

(56) $$\begin{cases} \mathrm{P}^{(1)}_{i,\lambda+1} = \mathrm{P}^{(1)}_{i,\lambda} + p^{(0)}_i \\ \mathrm{P}^{(1)}_{i,\lambda+2} = \mathrm{P}^{(1)}_{i,\lambda+1} + p^{0}_i \end{cases}$$

. . . .

(57) $$\begin{cases} \mathrm{P}^{(1)}_{i,\lambda-1} = \mathrm{P}^{(1)}_{i,\lambda} - p^{(0)}_i \\ \mathrm{P}^{(1)}_{i,\lambda-2} = \mathrm{P}^{(1)}_{i,\lambda-1} - p^{(0)}_i \end{cases}$$

. . . .

Next we compute the $\mathrm{P}^{(2)}_{i,\lambda}$. One set for a certain value of λ directly by formula (26), p. 106, this Journal, and for all the other values of λ by the following formulas:

$$\left.\begin{aligned} \mathrm{P}^{(2)}_{i,\lambda+1} &= \mathrm{P}^{(2)}_{i,\lambda} + \mathrm{P}^{(1)}_{i,\lambda+1} \\ \mathrm{P}^{(2)}_{i,\lambda+2} &= \mathrm{P}^{(2)}_{i,\lambda+1} + \mathrm{P}^{(1)}_{i,\lambda+2} \end{aligned}\right\} \qquad (58)$$

. . . .

$$\left.\begin{aligned} \mathrm{P}^{(2)}_{i,\lambda-1} &= \mathrm{P}^{(2)}_{i,\lambda} - \mathrm{P}^{(1)}_{i,\lambda} \\ \mathrm{P}^{(2)}_{i,\lambda-2} &= \mathrm{P}^{(2)}_{i,\lambda-1} - \mathrm{P}^{(1)}_{i,\lambda-1} \end{aligned}\right\} \qquad (59)$$

. . . .

We continue the computation of the $\mathrm{P}^{(m+n)}_{i,\lambda}$ in the same manner; compute one set for a certain value of λ directly, by means of formula (26), p. 106, and then the other sets for all the other values of λ are given by simple additions.

The same is done with regard to $\mathrm{P}'^{(m+n)}_{i,\lambda}$, $\mathrm{P}''^{(m+n)}_{i,\lambda}$, ...

4. Then are computed the $\underset{(i)}{\mathrm{P}}{}^{m,n}_{m,n}$, $\underset{(i)}{\mathrm{P}'}{}^{m,n}_{m,n}$, $\underset{(i)}{\mathrm{P}''}{}^{m,n}_{m,n}$, ... by means of (38), (47), (55), ...

Finally the $\mathrm{Q}^{m,n}_{m,n}$, $\mathrm{R}^{m,n}_{m,n}$, ... by means of (44), (51) and (52).

5. The coefficients $\underset{(i)}{\mathrm{P}}{}^{m,n}_{m,n}$, $\underset{(i)}{\mathrm{Q}}{}^{m,n}_{m,n}$, $\underset{(i)}{\mathrm{R}}{}^{m,n}_{m,n}$, ... are then arranged in tabular form, and those coefficients in which the lower and upper indices differ, computed by means of (30) and (31), as explained before.

The computation of the D of the different terms is done, as explained on p. 107 for the class 0. We had there the formula:

$$\mathrm{D}\underset{(i)}{\mathrm{P}}{}^{m,n}_{m,n} = -\lambda\, \underset{(i)}{\mathrm{P}}{}^{m,n}_{m,n} - (m+1)\, \underset{(i)}{\mathrm{P}}{}^{m+1,n}_{m+1,n} \qquad (60)$$

We have similarly

$$\mathrm{D}\underset{(i)}{\mathrm{P}'}{}^{m,n}_{m,n} = -\lambda\, \underset{(i)}{\mathrm{P}'}{}^{m,n}_{m,n} - (m+1)\, \underset{(i)}{\mathrm{P}'}{}^{m+1,n}_{m+1,n} \qquad (60)'$$

$$\mathrm{D}\underset{(i)}{\mathrm{P}''}{}^{m,n}_{m,n} = -\lambda\, \underset{(i)}{\mathrm{P}''}{}^{m,n}_{m,n} - (m+1)\, \underset{(i)}{\mathrm{P}''}{}^{m+1,n}_{m+1,n} \qquad (60)''$$

And then the formulas (44), (51) and (52) give:

$$\mathrm{D}\underset{(i)}{\mathrm{Q}}{}^{m,n}_{m,n} = \sum_0^m{}_e \sum_0^n{}_k\, \mathrm{D}\underset{(i)}{\mathrm{P}'}{}^{e,k}_{e,k} \qquad (61)$$

$$\mathrm{D}\underset{(i)}{\mathrm{Q}'}{}^{m,n}_{m,n} = \sum_0^m{}_e \sum_0^n{}_k\, \mathrm{D}\underset{(i)}{\mathrm{P}''}{}^{e,k}_{e,k} \qquad (62)^a$$

$$\mathrm{D}\underset{(i)}{\mathrm{R}}{}^{m,n}_{m,n} = \sum_0^m{}_e \sum_0^n{}_k\, \mathrm{D}\underset{(i)}{\mathrm{Q}'}{}^{e,k}_{e,k} \qquad (62)$$

As to the D of the terms with different upper and lower indices, they are reduced to the D of those with the same upper and lower indices by means of formulas, which differ from (30) and (31) only in the substitution of $\mathrm{DP}^{m',n'}_{m,n}$, $\mathrm{DQ}^{m',n'}_{m,n}$, ... for $\mathrm{P}^{m',n'}_{m,n}$, $\mathrm{Q}^{m',n'}_{m,n}$, ...

There is a simplification in the way of computing the coefficients of higher classes than 0, which it is well to note. In fact

$$\underset{(i)}{\mathrm{Q}}{}^{m,n}_{m,n} = \sum_0^m{}_e \sum_0^n{}_k\, \underset{(i)}{\mathrm{P}'}{}^{e,k}_{e,k} = \sum_0^{m_1}{}_e \sum_0^{n_1}{}_k\, \underset{(i)}{\mathrm{P}'}{}^{e,k}_{e,k} + \sum_0^{m_1}{}_e \sum_{n_1+1}^{n}{}_k\, \underset{(i)}{\mathrm{P}'}{}^{e,k}_{e,k}$$

$$+ \sum_{m_1+1}^{m}{}_e \sum_0^{n_1}{}_k\, \underset{(i)}{\mathrm{P}'}{}^{e,k}_{e,k} + \sum_{m_1+1}^{m}{}_e \sum_{n_1+1}^{n}{}_k\, \underset{(i)}{\mathrm{P}'}{}^{e,k}_{e,k}$$

(63)

or

$$\underset{(i)}{\mathrm{Q}}{}^{m,n}_{m,n} = \underset{(i)}{\mathrm{Q}}{}^{m_1,n_1}_{m_1,n_1} + \sum_0^{m_1}{}_e \sum_{n_1+1}^{n}{}_k\, \underset{(i)}{\mathrm{P}'}{}^{e,k}_{e,k} + \sum_{m_1+1}^{m}{}_e \sum_0^{n}{}_k\, \underset{(i)}{\mathrm{P}'}{}^{e,k}_{e,k} + \sum_{m_1+1}^{m}{}_e \sum_{n_1+1}^{n}{}_k\, \underset{(i)}{\mathrm{P}'}{}^{e,k}_{e,k}$$

If, therefore. $\mathrm{Q}^{m_1,n_1}_{m_1,n_1}$ has already been computed, the

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* The most simple computation would be for $\lambda = 0$, because

$$\mathrm{P}^{(m+n)}_{i,0} = p^{(m+n)}_i .$$

Still, if only certain terms are needed for the development of the perturbative function, it will be more advantageous to choose the value λ accordingly.

number of terms remaining in the double sums will be reduced. The following formulas will be especially useful.

$$(64)\qquad \underset{(i)}{\mathrm{Q}}{}^{m+1,\,n}_{m+1,\,n} = \underset{(i)}{\mathrm{Q}}{}^{m,\,n}_{m,\,n} + \sum_{0}^{n}{}_{k}\, \underset{(i)}{\mathrm{P}}{}'^{\,m+1,\,k}_{\,m+1,\,k}$$

$$(65)\qquad \underset{(i)}{\mathrm{Q}}{}^{m,\,n+1}_{m,\,n+1} = \underset{(i)}{\mathrm{Q}}{}^{m,\,n}_{m,\,n} + \sum_{0}^{m}{}_{e}\, \underset{(i)}{\mathrm{P}}{}'^{\,e,\,n+1}_{\,e,\,n+1}$$

Analogous formulas subsist for the $\mathrm{Q}'^{m,n}_{m,n}$, $\mathrm{R}^{m,n}_{m,n}$ and so on; and in like manner for the D of these different coefficients.

To conclude, I will show what simplifications can be obtained when Prof. Newcomb's original method is retained, *i.e.*, when the operators $\Pi^{m',n'}_{m,n}$ are computed directly by his method.

First of all, I remark again, that *all the operators* $\Pi^{m',n'}_{m,n}$ *with different upper and lower indices can be expressed linearly in function of the operators* $\Pi^{m,n}_{m,n}$ *in which the corresponding upper and lower indices are the same*, on this *by means of formulas* (28) *and* (29) of this paper. Our computation is therefore reduced to that of the symbol $\Pi^{m,n}_{m,n}$.

Now, it follows from (18), (19) on p. 106 of this Journal, that *all the symbols* $\underset{(i)}{\Pi}{}^{m,n}_{m,n}$, *for which the sum* $m+n$ *remains constant as well as the difference* $i-m$, *differ from each other only by the factor* $\frac{(-1)^m}{m!\,n!}$. If then, instead of $\underset{(i)}{\Pi}{}^{m,n}_{m,n}$ we compute the operator $\pi^{(m+n)}_{(i-m)}$, we obtain all the operators

$$(66)\qquad \ldots\ldots \underset{(i-2)}{\Pi}{}^{m-2,\,n+2}_{m-2,\,n+2}\,,\quad \underset{(i-1)}{\Pi}{}^{m-1,\,n+1}_{m-1,\,n+1}\,,\quad \underset{(i)}{\Pi}{}^{m,\,n}_{m,\,n}\,,\quad \underset{(i+1)}{\Pi}{}^{m+1,\,n-1}_{m+1,\,n-1}\ldots\ldots$$

by formula (18) on p. 106.

The symbols $\pi^{(m+n)}_{\lambda}$, as we have seen, are connected with each other by an important relation, namely, the relation (29) p. 107. This enables us to pass from the set of operators (66) to a new one.

$$(67)\qquad \ldots\ldots \underset{(i-1)}{\Pi}{}^{m-2,\,n+2}_{m-2,\,n+2}\,,\quad \underset{(i)}{\Pi}{}^{m-1,\,n+1}_{m-1,\,n+1}\,,\quad \underset{(i+1)}{\Pi}{}^{m,\,n}_{m,\,n}\,,\quad \underset{(i+2)}{\Pi}{}^{m+1,\,n-1}_{m+1,\,n-1}\,,\ldots\ldots$$

(where i is increased by unity) *by a simple addition*, in a way similar to that which we have found for the coefficients $\underset{(i)}{P}{}^{m,n}_{m,n}$. On the whole, this method differs from the one previously explained, only by the fact that there we applied the operators on the different letters A_i, B_i, C_i, ... directly, whereas here the application is to be made after the operators $\Pi^{m',n'}_{m,n}$ have been completely developed. The first method is, however, preferable for many reasons, of which one of the chief is, that it reduces the computation to dealing with small numbers, whereas in computing the operators $\Pi^{m,n}_{m,n}$ we have to deal with very large numbers, the disadvantage of which is obvious.

It will be, perhaps, desirable to give here some of the relations between the different operators $\Pi^{m',n'}_{m,n}$, which are more frequently to be used in case the $\Pi^{m',n'}_{m,n}$ be computed directly by Prof. Newcomb's method. .

The following ones are special cases of formulas (28) and (29).

$$\Pi^{n+2}_{n} = (n+2)\ \Pi^{n+2}_{n+2} - 2\mu\ \Pi^{n+1}_{n+1} - (\mu+n)\ \Pi^{n}_{n} \qquad (68)$$

$$\Pi^{o,\,n+2}_{o,\,n} = (n+2)\ \Pi^{o,\,n+2}_{o,\,n+2} - 2\nu\ \Pi^{o,\,n+1}_{o,\,n+1} - (\nu+n)\ \Pi^{o,\,n}_{o,\,n} \qquad (68)'$$

$$\Pi^{m,\,n+2}_{m',\,n} = (n+2)\ \Pi^{m,\,n+2}_{m',\,n+2} - 2\nu\ \Pi^{m,\,n+1}_{m',\,n+1} - (\nu+n)\ \Pi^{m,\,n}_{m',\,n} \qquad (69)$$

$$\Pi^{n+2,\,m}_{n,\quad m'} = (n+2)\ \Pi^{n+2,\,m}_{n+2,\,m'} - 2\mu\ \Pi^{n+1,\,m}_{n+1,\,m'} - (\mu+n)\ \Pi^{n,\,m}_{n,\,m'} \qquad (69)'$$

Finally, I will give some other relations between the different operators, but without demonstration, as the reader will easily verify them :

$$(m+1)\ \underset{(i)}{\Pi}{}^{n,\,m+1}_{n,\,m+1} + (n+1)\ \underset{(i+1)}{\Pi}{}^{n+1,\,m}_{n+1,\,m} = 0 \qquad (70)$$

$$n(n+1)\ \underset{(i)}{\Pi}{}^{m,\,n+2}_{m\;,\,n} + 2n(m+1)\ \underset{(i+1)}{\Pi}{}^{m+1,\,n+1}_{m+1,\,n-1} + (m+1)(m+2)\ \underset{(i+2)}{\Pi}{}^{m+2,\,n}_{m+2,\,n-2} = 0 \qquad (71)$$

$$\underset{(i-1)}{\Pi}{}^{m,}_{m',} = \underset{(i)}{\Pi}{}'^{\,m}_{\,m'} \qquad (72)$$

$$\underset{(i+1)}{\Pi}{}^{o,\,n}_{o,\,n'} = \underset{(i)}{\Pi}{}'^{\,o,\,n}_{\,o,\,n'} \qquad (72)'$$

$$m(m+1)\ \underset{(i+2)}{\Pi}{}^{m+2,\,n}_{m\;\;,\,n} + 2m(n+1)\ \underset{(i+1)}{\Pi}{}^{m+1,\,n+1}_{m-1,\,n+1} + (n+1)(n+2)\ \underset{(i)}{\Pi}{}^{m,\;\;n+2}_{m-2,\,n+2} \qquad (71)'$$

$$\mathrm{D}\underset{(i)}{\Pi}{}^{m,\,n}_{m,\,n} = -(i-m)\ \underset{(i)}{\Pi}{}^{m,\,n}_{m,\,n} - (m+1)\ \underset{(i)}{\Pi}{}^{m+1,\,n}_{m+1,\,n} \qquad (73)$$

Other relations can be deduced from the formulas relating to the coefficients

$$\mathrm{P}^{m',\,n'}_{m,\,n}\,,\quad \mathrm{Q}^{m',\,n'}_{m,\,n}\,,\quad \mathrm{R}^{m',\,n'}_{m,\,n}\,,\quad \text{and so on.}$$

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THE PROBABLE REVOLUTION OF THE ORBIT OF THE INNER SATELLITE OF *MARS*.

By W. W. Campbell.

My observations of *Phobos*, made between October 25 and November 15, show that the eastern elongation occurs at a considerably greater distance from the planet than the western elongation does. Prof. Hall's observations in 1877 showed unmistakably that the western elongation-distance was then considerably greater than the eastern. The relative positions of the *Earth* and *Mars* at the times of the 1877 and 1894 measures were slightly different, but that fact accounts for only a very small part of the change. The greater part of the change has probably been produced by a revolution of the line of apsides of the orbit.

There are strong indications from the observations of *Deimos* that the orbit of that satellite has been similarly transformed; but the evidence is not so conclusive as in the case of *Phobos*, since the orbit of *Deimos* is nearly circular.

The observations will be published later.

Mt. Hamilton, 1894 *Nov.* 15.

ON CHANDLER'S NEW SHORT-PERIOD VARIABLE.

By PAUL S. YENDELL.

I began observations upon this star 1894 August 16, in compliance with a request from Dr. Chandler, accompanied by the bare statement that he believed the star to be a variable of short period and small light-range.

A few weeks' watching convinced me that the star was really variable to the extent of about four-tenths of a magnitude, in a period of between four and five days, and a summing up of my observations in the latter part of September, gave a period differing by only a few thousandths of a day from that published by Chandler in *A.J.* 329.

Maxima have been observed on the following dates:

	Wt.
1894 Aug. 21.4 Local M.T.	2
30.5	2
Sept. 20.4	3
Oct. 1.3	1
19.2	3

The reductions on which the above maxima depend are necessarily rough, as a sufficient number of observations for the formation of a serviceable mean light-curve has not yet been obtained. The general run of the observations, however, leaves no doubt of the star's variability and periodicity.

Dorchester, Mass., 1894 *November* 10.

This confirmation now permits the assignment of the definitive notation, 6854 *Y Aquilae*. — Ed.

NEW VARIABLE IN *HYDRA*, SDM. 14°2893.

$9^h\,28^m\,34^s.9\quad -14°\,2'.8$ (1855).

Communicated by Prof. Wm. Harkness, Astronomical Director, Naval Observatory.

In course of observation of the Washington Zone —13° 50′ to —18°10′, I have discovered that DM. —14°2893 is variable. From the published Munich observations, from the original *Durchmusterung* observations, kindly furnished by Dr. Küstner, Director of the Bonn Observatory, and from observations visual and photographic kindly furnished by Prof. E. C. Pickering, Director of the Harvard College Observatory, Assistant Astronomer Paul of this observatory has derived the following approximate elements.

1892 March 22 $\quad 2412180^d + 296\,E\ (9^M.2 - \text{below } 11^M)$.

A minimum occurs about 1895 Jan. 21, and a maximum occurs about 1895 June 18.

I defer publishing the data in detail until materials are obtained by following the star through a maximum, when I intend to make a more complete determination of the elements.

Aaron N. Skinner,
Assistant Astronomer.

Washington, 1894 *December* 12.

NEW ASTEROIDS.

Two more small planets were discovered photographically by Wolf at Heidelberg, Nov. 4, and one by Borrelly at Marseilles, Nov. 19. Their positions are given as

	M		h m			h m	° ′
BF	$11\frac{1}{2}$	Nov. 4	9 45	Heidelberg M.T.	α = 3 12.7	δ = +11 7	
		7	10 36	" "	3 10.3	10 37	
BG	11	Nov. 4	9 45	" "	α = 3 7.2	δ = +12 51	
		7	10 36	" "	3 4.7	12 21	
BH	$12\frac{1}{2}$	Nov. 19	9 47.0	Marseilles "	α = 3 14 5s	δ = +15 13 48″.	Daily motion, —60s in α, and 2′ S.

CORRECTION.

On comparing our observations of the transit of *Mercury*, (*A.J.*, No. 330), with those at other stations, I find that, owing to an oversight in respect to sign, I have committed an absurd error in reducing the observed contacts to the center of the earth. The true value of the reduction is — $12^s.3$ instead of $+7^s.6$, and all the reduced or geocentric times as printed should be diminished by $19^s.9$. The observed times are correct as they stand.

C. A. Young.

Princeton, 1894 *Dec.* 8.

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New Variable in Hydra SDM. —14°2893, by Mr. A. N. Skinner.
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NOTES ON VARIABLE STARS, — No. 6,

By HENRY M. PARKHURST.

In the use of the deflector with the full aperture, when the accuracy of the position of the transit wire is essential, I have found it necessary frequently to redetermine its position. Including a lucid star in a series, makes it easy to correct for any displacement of the transit wire, from flexure or otherwise.

Results of Observations.

No.	Star	Phase	Observed Date		E	Corr.	W	Remarks
			Julian	Calendar				
5157	*S Bootis*	Max.	2961	1894 May 12	42	−27	5	
5194	*V Bootis*	Max.	2976	May 27	14	−27	5	Sky unfavorable.
5237	*R Bootis*	Max.	3009	June 29	59	− 3	5	
5249	*V Librae*	Max.	3006	June 26	12	—	0	Probably at least two months ahead of element.
5338	*U Bootis*	Min.	2977	May 28	30	−20	5	Revised elements, *A.J.* 319.
"	"	Max.	3058	Aug. 17	30	−29	3	" " "
5430	*T Librae*	Max.	3055	Aug. 14	25	—	0	Prediction; invisible six weeks before max.
5438	*Y Librae*	Max.	3015	July 5	37	+11	1	Revised elements. A very faint max.
5494	*S Librae*	Max.	2980	May 31	38	−19	2	Clouds and moon interrupted observations.
5501	*S Serpentis*	Max.	2990	June 10	66	+23	4	Besides the sine-correction of +41 days.
5511	*RS Librae*	Max.	2969	May 20	8	—	0	Prediction; diminishing in June and July.
5583	*X Librae*	Max.	3058	Aug. 17	33	−15	1	Probably later than my elements indicate.
5644	*Z Librae*	Max.	3005	June 25	20	− 4	1	Perhaps earlier.
5675	*V Coronae*	Max.	3011	July 1	16	+28	5	No secondary max. observed.
5677	*R Serpentis*	Min.	2950	May 1	69	−21	1	Adopting the correction in *A.J.* 308.
"	"	Max.	3114.7	Oct. 12	69	− 7.2	9	A brighter max. than last year.
5704	*RR Librae*	Max.	3033	July 23	12	− 1	5	Disregarding the first observation.
5761	*Z Scorpii*	Max.	3056	Aug. 15	21	+22	1	Estimation, from correction in 308.
5830	*R Scorpii*	Max.	3014	July 4	51	−26	5	
5831	*S Scorpii*	Max.	3007:	June 27	118	− 6	1	Disregarding the observations a month later.
5887	*V Ophiuchi*	Min.	3061	Aug. 20	25	—	5	Makes $M-m = 171$. Revised elements.
5931	*S Ophiuchi*	Max.	3063	Aug. 22	58	+ 8	1	Probably later.
5950	*W Herculis*	Min.	2991	June 11	20	− 2	2	Possibly preceded May 29.
"	"	Max.	3130.3	Oct. 28	20	+12	9	
6044	*S Herculis*	Max.	3096.6	Sept. 24	45	+52.6	9	Disagreement from elements increasing.
6132	*R Ophiuchi*	Min.	2987	June 7	—	—	0	Assumed min; first visible a month later. Observations not yet reduced.
6207	*Z Ophiuchi*	Min.	3120	Oct. 18	—	—	1	Probably not earlier.
6512	*T Herculis*	Max.	2985	June 5	58	+15	5	
"	"	Min.	3064	Aug. 23	59	+ 7	3	
"	"	Max.	3150.1	Nov. 17	59	+15	9	
6682	*X Ophiuchi*	Max.	3004	June 24	—	—	0	Prediction, 319; see also 318; obs. interrupted.

INDIVIDUAL OBSERVATIONS.

5157 *S Bootis.*

Julian d	Calendar 1894	Mag.
2936	Apr. 17	8.96_2
2958	May 9	8.04_2
2983	June 3	8.47_2
2990	10	9.23_2

5194 *V Bootis.*

2895	Mar. 7	9.7
2922	Apr. 3	9.2
2936	17	8.65_2
2959	May 10	7.78_2
2983	June 3	7.42_2
2992	12	7.83_3
3002	22	7.51_2
3015	July 5	8.39_2

5237 *R Bootis.*

2988	June 8	8.0
2990	10	7.64_2
2998	18	7.89_2:
3003	23	6.60_2
3008	28	7.69_2
3013	July 3	7.03_3
3015	5	7.40_2
3017	7	7.10_2
3020	10	7.44_2:
3021	11	7.34_2
3023	13	7.55_2
3030	20	$7\ 89_2$
3035	25	7.36_2
3050	Aug. 9	9.29
3058	17	10.89
3065	24	10.47
3083	Sept. 11	10.7]

5249 *V Librae.*

2958	May 9	11.7
2976	27	12.6
3002	June 22	13.2]
3013	July 3	12.7]
3034	24	12.7]

5338 *U Bootis.*

(Continued from 308.)

2922	Apr. 3	11.27_2
2945	26	12.2
2957	May 8	12.37_2
2983	June 3	12.6
3011	July 1	11.7
3046	Aug. 5	10.5
3065	24	10.3
3083.5	Sept. 11	11.0
3092.6	20	11.0
3101.5	29	11.11_2
3108.5	Oct. 6	11.49_2
3120.5	18	11.3

5430 *T Librae.*

Julian d	Calendar 1894	Mag.
2988	June 8	11.2]
3011	July 1	11.7]
3034	24	10.8
3037	27	10.93_2

5438 *Y Librae.*

(Continued from 308.)

2997	June 17	10.0]
2998	18	11.7]
3007	27	11.7:
3015	July 5	11.3
3035	25	11.5]
3038	28	11.5]
3047	Aug. 6	11.7]

5494 *S Librae.*

(Continued from 308.)

2958	May 9	9.4
2961	12	8.76_2
3002	June 22	8.95_2
3017	July 7	9.21
3037	27	9.46

5501 *S Serpentis.*

2945	Apr. 26	11.2
2957	May 8	10.1
2976	27	9.3
2985	June 5	9.08_2
2992	12	8.80_2
2998	18	9.51_2

5511 *RS Librae.*

2988	June 8	9.6
3011	July 1	10.25_2
3017	7	9.85_2
3035	25	11.2

5583 *X Librae.*

(Continued from 308.)

2983	June 3	12.5]
3001	21	12.4]
3011	July 1	12.6]
3034	24	12.6]
3046	Aug. 5	12.4
3047	6	12.3
3058	17	10.9

5644 *Z Librae.*

3001	June 21	11.3
3011	July 1	11.4
3034	24	12.0
3046	Aug. 5	12.0]

5675 *V Coronae.*

Julian d	Calendar 1894	Mag.
2945	Apr. 26	9.7
2958	May 9	10.3
2961	12	9.52_2
2978	29	9.77_2
2990	June 10	9.34_2
2998	18	9.32_2
3008	28	9.28_2
3015	July 5	9.12_2
3017	7	9.19_2
3020	10	9.41_2

5677 *R Serpentis.*

(Continued from 308.)

2945	Apr. 26	12.3]
2957	May 8	12.8:
2976	27	12.7:
2983	June 3	12.6
3011	July 1	12 3
3038	28	10.8
3065	Aug. 24	8.5
3073	Sept. 1	8.27_3
3084.5	12	7.39_2
3096.5	24	6.56_2
3107.5	Oct. 5	6.91_2
3108.5	6	6.61_2
3112.5	10	6.38_2
3113 5	11	6.60_2
3114.5	12	6.57_2
3117.5	15	6.32_2
3121.5	19	7.01_2
3129.4	27	6.54_2

5704 *RR Librae.*

3013	July 3	7.9
3015	5	8.3:
3017	7	8.03_2:
3019	9	8.31_2
3020	10	8.52_2
3027	17	8.13_2
3035	25	8.17_2
3058	Aug. 17	8.99_2

5761 *Z Scorpii.*

(Continued from 308.)

3013	July 3	11.0
3017	7	11.28_2
3046	Aug. 5	10.65_2
3058	17	10.48_2

5830 *R Scorpii.*

3001	June 21	11.0
3003	23	11.06_2
3011	July 1	10.32_2

5830 *R Scorpii.*—Cont.

Julian d	Calendar 1894	Mag.
3017	7	10.29_2
3030	20	10.82_2
3037	27	10.92_2
3058	Aug. 17	11.87
3062	21	12.2:
3063	22	12.2

5831 *S Scorpii.*

(Continued from 308.)

3001	June 21	12.6
3003	23	12.52_2
3011	July 1	12.50_2
3017	7	12.89_2
3030	20	11.3]
3037	27	11.87_2
3058	Aug. 17	12.2:
3062	21	12.2]
3063	22	12.5]

5887 *V Ophiuchi.*

(Continued from 308.)

3026	July 16	9.66_2
3038	28	9.3
3050	Aug. 9	9.96_2
3063	22	10.31_2
3078.5	Sept. 6	9.8
3083.5	11	9.6
3092.6	20	9.7
3095.5	23	9.22_2

5931 *S Ophiuchi.*

2983	June 3	12.0]
3013	July 3	11.1
3058	Aug. 17	11.6]:
3062	21	8.9:
3063	22	8.4

5950 *W Herculis.*

2978	May 29	13.1
3010	June 30	12.9
3020	July 10	12.4
3047	Aug. 6	11.2
3084.5	Sept. 12	8.90_2
3096.5	24	8.93_2
3108.5	Oct. 6	8.29_2
3114.5	12	8.33_2
3117.5	15	8.17_2
3122.5	20	7.95_2
3129.5	27	8.07_2
3135.5	Nov. 2	7.88_2
3144.5	11	8.22_2
3145.5	12	8.50_2
3148.5	15	8.65_2

6044 *S Herculis.*

(Continued from 311.)

Julian d	Calendar 1894	Mag.
3052	Aug. 11	8.65
3068	27	8.28_2
3077	Sept. 5	7.66_2
3087.5	15	7.27_2
3093.5	21	6.97_2
3094.6	22	7.18_2
3095.5	23	6.85_2
3101.5	29	7.22_2
3108.5	Oct. 6	7.12_2
3114.5	12	7.90_2

6207 *Z Ophiuchi.*

3000	June 20	8.6
3013	July 3	8.93_2
3050	Aug. 9	9.76_2
3065	24	10.6
3078.5	Sept. 6	10.48_2
3095.5	23	11.1
3103.5	Oct. 1	11.75_2
3108.5	6	11.91_2
3120.5	18	12.1
3134.5	Nov. 1	11.7]

6512 *T Herculis.*

2945	Apr. 26	10.0
2958	May 9	9.2
2962	13	9.39_2
2978	29	8.61_2
2992	June 12	8.23_2
2998	18	8.94_2
3050	Aug. 9	13.6
3065	24	13.8
3078.5	Sept. 6	13.6
3092.6	20	11.3
3095.5	23	11.91
3121.5	Oct. 19	9.85_2
3129.5	27	9.70_2
3133.5	31	9.61_2
3137.6	Nov. 4	8.88_2
3139.5	6	8.93_2
3144.5	11	8.82_2
3145.5	12	8.87_2
3148.5	15	8.76_2
3152.4	19	8.62_2
3155.5	22	8.80_2
3159.5	26	9.30_2
3160.5	27	9.06_2

6682 *X Ophiuchi.*

(Continued from 311.)

2959	May 10	8.50_2
3072	Aug. 31	6.62_2
3087.5	Sept. 15	7.17_2
3096.5	24	6.86_2
3107.5	Oct. 5	6.99_2

Comparison-Stars.

In the lists of comparison-stars, *V* indicates photometric observations by Müller and Kempf, these stars having sometimes also been observed with the meridian photometer.

5194 *V Bootis.*

B	+39°2764	6.42	0M
E	+40°2785	7.47	6M
1*E*	+39°2760	6.81	2M
1*G*	+40°2808	8.07	0M
H	+40°2793	8.87	2
I	+39°2778	8.38	2
K	+40°2792	9.14	3
N	+39°2770	9.38	8
P	+40°2797	8.84	2M
Q	+40°2800	9.53	1M
R	+39°2774	8.98	5
1*R*	+39°2777	9.39	1
S	+39°2771	10.20	3
U	+39°2779	10.65	1
W	+29°2769	9.92	0M

5194 *V Bootis.*—Cont.

X	+39°2782	10.07	0M
2*X*	+39°2785	10.12	0M

5237 *R Bootis.*

Q	+27°2413	4.71	6M
H	+26°2592	7.87	9
I	+28°2365	7.54	21
1*I*	+28°2366	8.37	17
K	+27°2404	8.12	19
L	+27°2396	8.75	22
M	+28°2368	8.42	7
N	+27°2403	9.38	22

5438 *Y Librae.*

B	−4°3840	6.29	1M

5438 *Y Librae.*—Cont.

D	−4°3818	7.39	2M
F	−4°3855	6.54	1M
J	−5°4034	7.80	2
N	−5°4018	8.47	2M
P	−5°4060	8.02	1M
Q	−4°3858	9.23	1M
1*Q*	−5°4029	8.94	3
2*Q*	−5°4038	9.14	5
R	−5°4040	8.69	3M
S	−5°4033	9.81	4
W	−5°4031	10.19	5
X	−4°3843	10.02	3M
Y	−5°4028	11.20	4
d	1*s*7*f* 1*Q*	11.17	2
e	2*s* *V*	11.38	2

6207 *Z Ophiuchi.*

E	+0°3690	7.06	1V
1*E*	+1°3421	7.20	0V
F	+0°3678	7.79	2V
N	+1°3415	8.44	1M
1*N*	+1°3423	8.83	1
X	+1°3418	9.65	4
1*X*	+1°3425	9.82	1M
Z	+1°3420	10.22	5
1*Z*	+1°3419	10.66	3
a	8*s* 1*E*	9.22	2
b	3*f* *a*	10.71	2
c	3*s*1*f* *V*	10.72	2
d	1*n*3*p* *V*	10.73	5
g	2*s*1*f* *V*	11.65	1

ON THE PARALLAX OF β *CASSIOPEAE*,

By S. C. CHANDLER.

In the *Bulletin* of the St. Petersburg Academy (1894 Oct., No. 2), Mr. Kostinsky has a very interesting paper on the parallax of this star. As I happen to have in my desk some computations bearing on the same subject, a brief note upon them may not be out of place.

Referring to *A.J.*, XIII, p. 65 foll., I have derived for this star, after correcting for the 428-day term of the latitude-variation, (see table, p. 66),

$$Y = +0''.224\text{ , wt. 7 ;}\quad Z = +0''.194\text{ , wt. 5}$$

Substituting these in eq. (28), *A.J.* XII, p. 177, we find

$$\begin{array}{llr} -0.198\,\pi = +0''.224\;-\eta\;-0.851\,u & & \text{(wt. 7)} \\ +0.853\,\pi = +0.194\;-\zeta\;-0.198\,u & & \text{(wt. 5)} \end{array}$$

which give

$$\pi = +0''.132\;+0.354\,\eta\;-1.090\,\zeta\;+0.085\,u$$

This equation shows that the parallax is nearly independent of the aberration. Thus, with the constant 20″.500, we have $u = +0''.055$; and the correction to the parallax of only +0″.005. Further, whatever values of η and ζ are assumed, the former is probably positive and the latter negative, and their numerical values certainly less than, say, 0″.15 in each case. The parallax +0″.132 consequently is a minimum value, from these observations. If we take $\eta = +0''.104$, $\zeta = -0''.013$, found on p. 66 from all of Nyrén's 24 stars, we get a parallax of +0″.181; which accords sufficiently well with Kostinsky's result from the same observations, +0″.167.

But, besides these 26 observations of Nyrén in 1880–81, and Kostinsky's 35 observations in 1891–93, from which he gets a parallax of +0″.14, we have Struve's 37 observations in 1841–42 with the same instrument; and these, it seems to me, ought to be taken into the account. At the bottom of p. 58, *A.J.* XII, I have found

$$\begin{array}{ll} Y = +0''.049\;+0.869\,y\;+0.238\,z & \text{wt. 21} \\ Z = -0.215\;-0.521\,y\;+0.899\,z & \text{wt. 13} \end{array}$$

Substituting these in eq. (28) we find,

$$\begin{array}{lr} & \text{Wt.} \\ -0.207\,\pi = +0''.049\;+0.869\,y\;+0.238\,z\;-\eta\;-0.851\,u & 21 \\ +0.851\,\pi = -0.215\;-0.521\,y\;+0.899\,z\;-\zeta\;-0.207\,u & 13 \end{array}$$

which give

$$\pi = -0''.251\;-0.925y\;+0.864\,z\;+0.421\eta\;-1.073\zeta\;+0.137u$$

Here, again, the parallax is nearly independent of the aberration; the correction corresponding to the constant 20″.500 being only +0″.007. Whatever values we attribute to the constants of the latitude-variation, within reasonable limits as to their possible values, we get a negative parallax between one-sixth and one-quarter of a second. For example, with the two sets of values for y, z, η, ζ, on pp. 58 and 59, we have the parallaxes −0″.173 and −0″.262; and from those furnished by eq (52), −0″.194; and so on.

This result, therefore, appears to me to throw some doubt on the conclusion that β *Cassiopeae* has any considerable parallax: for, since Struve's observations must be reckoned with, and the result which they give is not notably, if at all, inferior to the others, the combination of all, with any reasonably assigned weights, would not give a parallax of over, say, +0″.05.

As to Pritchard's result, one can not be blamed for reserving judgement as to its trustworthiness, since the apparent presence of systematic errors in his work, might easily bring down his assigned value, +0″.154, to one-half, or even one-third.

Nevertheless Kostinsky's results have a significance which requires that the examination of the star should be undertaken by differential methods of observation.

Cambridge, 1894 *Dec.* 24.

OBSERVATIONS OF THE TRANSIT OF *MERCURY*, 1894 NOVEMBER 9, 10.

MADE AT THE CHAMBERLIN OBSERVATORY, UNIVERSITY PARK, COLO.

The following observations were made by H. A. Howe, with the 20-inch equatorial, having a power of 220 on a polarizing eye-piece; the aperture was reduced to 12 inches.

Local Mean Time.	
h m s	
Nov. 9 20 57 22	One-fifth, or one-sixth of planet's diameter already on the sun.
20 58 49	Second contact.
10 2 11 40	Third contact.
2 13 22	Fourth contact.

The planet was looked for in vain before first contact, and after last contact; no ring of light was seen at any time. Just before second contact, the definition being poor, there was a marked black drop; but previous experiments with an artificial *Mercury* had shown that this phenomenon was due almost entirely to bad seeing, and the observer found that better definition occurring at the time of second contact enabled him to get a good observation. "Not yet" was noted 4^s before, and "past" 7^s after the times given above for second contact. Satellites, shadings on the planet, which was notably darker than the umbras of the sunspots, and evidences of an atmosphere could not be seen. Dense clouds obscured the sun before the time of third contact, but a rift came at the proper time, and the definition was superb, the planet being as sharply defined, as if cut out of metal with a punch. For some seconds before third contact there was a slight darkening of the solar surface between the sun's limb and the advancing edge of *Mercury*, and two or three seconds before contact a very minute black drop formed. The uncertainty of the observation of internal contact did not seem to be as much as three seconds. At fourth contact there was a trifling undulation of the sun's limb, but a well defined, though exceedingly shallow notch was seen at the time noted. Five seconds thereafter the planet had certainly disappeared.

Observations of H. E. Russell. — Prof. Russell used the six-inch Grubb equatorial, with a power of 99.

Local Mean Time.	
h m s	
Nov. 9 20 57 35	Between one-fourth and one-third of *Mercury's* diameter was on the sun.
20 58 51	Second contact: no black drop.
10 2 11 13	Third contact: thought to be noted too early.
2 13 3	Fourth contact: difficult in clouds.

No ring of light was seen at any time, and *Mercury* was invisible when off the sun's disc. Before third contact the black drop seemed to form suddenly, and contact was noted soon after. "Not" was noted 2^s before second contact, and "past" 4^s after contact. "Not" was noted 6^s before third contact, and "past" 26^s after contact. "Past" was noted 11^s after fourth contact.

Observations by Mrs. H. A. Howe. — Mrs. Howe used the five-inch finder of the 20-inch, with a power of 120.

The seconds of the morning observations were lost; the chronograph pen failed to work properly.

Local Mean Time.	
h m s	
Nov. 10 2 11 39	Third contact: no black drop.
2 12 54	Fourth contact: notch seen again however, a few seconds afterwards.
2 13 3	"Past."

OBSERVATIONS OF THE SATELLITES OF *MARS*,

By ORMOND STONE.

The following observations were made with the twenty-six inch refractor of the Leander McCormick Observatory. The reductions were made by Mr. H. Y. Benedict. In each case *Phobos* was compared with *Deimos*. The angles given are the means of two comparisons; the distances are double distances, except those of Oct. 1, which are each the mean of three single distances.

October 1, 1894.

Eastern Time.	p	Eastern Time.	s
h m s	°	h m s	″
10 23 16	65.1	13 36 9	99.6
13 22 12	48.0	13 59 0	94.6
14 24 13	39.9	. . . .	. . . .

November 1, 1894.

Eastern Time.	p	Eastern Time.	s
h m s	°	h m s	″
8 17 9	233.7	8 25 8	92.7
11 16 40	213.1	8 32 9	91.8
11 45 42	214.0	11 29 26	37.6
12 54 20	214.2	11 35 30	36.8
12 21 42	216.0	12 4 44	33.7
. . . .	. . . .	12 10 52	33.9

November 4, 1894.

Eastern Time.	p	Eastern Time.	s
h m s	°	h m s	″
12 0 52	56.0	12 12 6	40.5
12 36 1	58.8	12 20 38	40.8

COMETS 1847 V AND 1888 V.

Letter from Mr. Hind to the Editor.

You will remember our conversation relating to the orbit of Comet 1847 V (Brorsen July 20) which you gave in the first volume of the *Astronomical Journal*. That orbit, as you remark, left decided negative errors in August, especially in right-ascension, and you did not consider it definite. I have now carried out the intention I expressed to you, of ascertaining what effect upon the period of revolution the correction of those errors would produce, or rather the tendency of it. Making use of a position founded upon the Altona and Hamburg observations of July 21, a normal carefully deduced for August 14, and the last observation at Hamburg on September 12, I have obtained the following orbit:

$$\begin{array}{rcl} T & = & 1847 \text{ Sept. } 9.46190 \text{ Greenw. M.T.} \\ & & \quad\;\; {}^{\circ} \quad\; {}' \quad\;\; {}'' \\ \pi & = & \;\;79 \;\;\; 3 \;\; 55.2 \\ \Omega & = & 309 \; 53 \; 34.6 \\ i & = & \;\;19 \; 10 \; 16.0 \end{array} \left.\vphantom{\begin{array}{c}a\\a\\a\end{array}}\right\} 1847.0$$

$$\begin{array}{rcl} \phi & = & 77 \; 43 \;\;\; 0.5 \\ \log a & = & 1.3295204 \\ \log p & = & 9.9852342 \\ \text{Period} & = & 98.69 \text{ years.} \end{array}$$

The middle place is thus represented

$$(\text{C}-\text{O}) \quad \Delta\lambda \cos\beta = +2''.3, \quad \Delta\beta = -0''.3$$

This period it will be observed is greater than your determination and that of D'Arrest, but less than Quirling's. Of course it has no pretensions, under the circumstances, to be considered definite; and probably to fix the period as accurately as the conditions allow, it will be desirable to reduce the observations as far as practicable again with the best positions for comparison-stars.

In the above orbit, in longitude 293° 45′, corresponding to true anomaly 213° 40′, the comet's distance from the orbit of *Jupiter* is 0.46, perhaps a sufficient indication of the cause of periodicity.

I avail myself also of the present opportunity to send you an orbit of the comet 1888 V, which I worked out some time since, expecting to obtain a result not very different from that published by Mr. Searle in your Journal. The period, however, is considerably longer. I believe the orbit has been stated to be under definite computation. My elements depend upon the observations at Mt. Hamilton, on October 31; Strassburg, 1889 January 27; and Dresden, May 1.

$$\begin{array}{rcl} T & = & 1888 \text{ Sept. } 12.81248 \text{ Greenw. M.T.} \\ & & \quad\;\; {}^{\circ} \quad\; {}' \quad\;\; {}'' \\ \pi & = & \;\;68 \; 24 \; 17.1 \\ \Omega & = & 137 \; 33 \;\;\; 5.5 \\ i & = & \;\;56 \; 23 \; 28.6 \end{array} \left.\vphantom{\begin{array}{c}a\\a\\a\end{array}}\right\} 1888.0$$

$$\begin{array}{rcl} \phi & = & 83 \; 19 \; 55.87 \\ \log a & = & 2.3542167 \\ \log p & = & 0.4839770 \\ \text{Period} & = & 3398^{\text{y}}.8 \end{array}$$

For the middle observation, (C—O),

$$\Delta\lambda \cos\beta = +1''.0, \quad \Delta\beta = +0''.1$$

In this orbit we have also a near approach to that of *Jupiter*; in longitude 316° the distance is only 0.27.

J. R. Hind.

3 *Cambridge Park, Twickenham*, 1894 *Nov.* 21.

MEASURES OF THE POLAR AND EQUATORIAL DIAMETERS OF *MARS*,

By C. A. Young.

The following measures were made at the Halsted Observatory with the 23-inch equatorial and filar micrometer. The eyepiece was a Steinheil "monocentric" giving a magnifying power of 475. On both nights the seeing was very fine during the evening, so that much of the time while the measurements were going on, both of the satellites were conspicuous with the planet in the field.

On both nights, however, clouds or fog appeared about midnight, and made it impossible to obtain a corresponding series of measures after the planet had passed the meridian.

Each of the measures was a "double-distance," involving twelve wire-settings; and during the observations the coincidence-point was repeatedly changed in order to obviate bias in the readings of the micrometer head.

The position circle was set for the polar and equatorial diameters according to Marth's ephemeris.

The measures have been corrected for differential refraction, and for the effect of a very slight phase on the planet's southern limb; in no case however did the total correction exceed 0″.011. The observations were made on Oct. 19th and 20th, the latter being the date of opposition.

The difference between the polar and equatorial diameters comes out practically insensible, but I do not regard this result as invalidating the slight oblateness ($\frac{1}{219}$) deduced from my much more extended series of observations in 1879, as the loss of the morning observations made it impossible in this case to eliminate the slight systematic error which affects my measure of lines of varying inclination to the vertical.

A single measure was made of the diameter lying from N.W. to S.E. at an angle of 45° with the axis.

The mean diameter of the planet, reduced to distance unity, comes out 9″.757. This, like all filar-micrometer measures, is, of course, too large on account of irradiation; but considering the steadiness of the image, and the rather high power employed, which prevented all sensation of "glare," I think the correction must be small, not much, if at all, exceeding 0″.1.

			Measured diameter.	Reduced to dist. unity.	
			″	″	
Polar Diameter,	Oct. 19,	(1)	22.44	9.768	9″.748.
	19,	(2)	22.43	9.764	
	Oct. 20,	(1)	22.36	9.746	
	20,	(2)	22.29	9.716	
Equat. Diameter,	Oct. 19,	(1)	22.45	9.773	9″.765.
	19,	(2)	22.42	9.759	
	Oct. 20,	(1)	22.38	9.755	
	20,	(2)	22.42	9.772	
Diam. N.W. to S.E.,	Oct. 20,		22.39	9.759	
General mean (red. to distance unity)				**9″.757**	

Princeton, N.J., 1894 *Nov.* 23.

COMET *e* 1894 (E. SWIFT).

Prof. BARNARD obtained two more observations of this comet with the 12-inch equatorial of the Lick Observatory in November, but the very unfortunate weather had prevented him from securing any others at the date of the latest mail.

1894 Mt. Hamilton M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Nov. 28 8 29 34	4	12 , 4	+0 40.49	—9 44.5	22 41 28.97	−10 24 43.1	9.438	0.796
30 7 1 10	5	12 , 4	−0 46.64	−5 28.5	22 47 6.23	− 9 44 45.2	9.029	0.807

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
4	22 40 45.49	+2.99	−10 15 12.3	+13.7	Argent. G. C. 31007
5	22 47 49.87	+3.00	− 9 39 30.8	+14.1	W. Bessel XXII, 954

Prof. ORMOND STONE obtained another position with the 26-inch of the McCormick Observatory of the University of Virginia.

1894 Local M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Dec. 19 8 8 57	. .	16	−0 10.80	. . .	23 39 48.82	. . .	9.436	. . .
8 30 18	. .	5	. . .	−4 6.7	. . .	−3 16 12.8	. . .	0.757

Mean Place for 1894.0 of Comparison-Star.

α	Red. to app. place	δ	Red. to app. place	Authority
h m s	s	° ′ ″	″	
23 39 56.58	+3.04	−3 12 24.3	+18.2	Munich II, 13075

From the positions observed at Mt. Hamilton, Nov. 21, at the Catholic University in Washington, Nov. 28, and at Northfield, Dec. 14, Rev. G. M. SEARLE deduced parabolic elements, which represent the middle place within 15″ in longitude, and exactly in declination. These are

$$T = 1894 \text{ Oct. } 22.2212 \text{ Greenw. M.T.}$$

$$\left.\begin{aligned} \Omega &= 44^\circ\ 25'\ 58'' \\ \omega &= 304\ 29\ 56 \\ i &= 3\ 11\ 49 \end{aligned}\right\} 1894.0$$

$$\log q = 0.181690$$

The ephemeris of Dr. CHANDLER in *A.J.* 331 represented the comet's course very closely. A continuation from Dec. 30 on, from SEARLE's elements, was distributed by Mr. RITCHIE on Dec. 29, as a Special Circular of the *Science Observer*. This follows.

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

	App. α	App. δ	log Δ	Brightn.
	h m s	° ′		
1894 Dec. 30.5	0 8 17	+0 16.0	0.2123	0.39
1895 Jan. 3.5	0 18 22	+1 30.3	0.2275	0.35
7.5	0 28 15	+2 42.5	0.2426	0.32
11.5	0 37 58	+3 52.7	0.2577	0.29
15.5	0 47 32	+5 0.8	0.2727	0.26

Prof. S. J. BROWN has sent an observation, made Dec. 17, with the 26-inch telescope of the Naval Observatory,

Dec. 17 $11^{h}\ 57^{m}.4$ Gr. M.T. $\alpha = 23^{h}\ 34^{m}\ 17^{s}.18$, $\delta = -3^\circ\ 57'\ 48''.0$

The apparent place of the comparison-star as determined with the Washington meridian-circle, Dec. 19, is

$$\alpha = 23^{h}\ 34^{m}\ 2^{s}.63\ ,\quad \delta = -4^\circ\ 3'\ 34''.2$$

NEW ASTEROIDS.

Four more small planets have been discovered by CHARLOIS, at Nice. Their positions are given as follows:

	M	h m s	h m s	° ′ ″	
BJ	11	Nov. 24 12 56.6 Nice M.T.	α = 2 24 37.8,	δ = − 1 57 3	Daily motion, −36ˢ in α, and 4′ northward
BK	13.5	" 30 9 19.0	4 7 16	+22 13	−56ˢ " " 4′ southward
BL	13.5	Dec. 1 9 53.0	4 53 16	+22 27	−60ˢ " " 2′ "
BM	12	" 19 9 39.0	5 26 0	+10 31	−60ˢ " " 3′ "

OBSERVATIONS OF COMET *e* 1894 (E. SWIFT),

MADE AT THE CHAMBERLIN OBSERVATORY OF THE UNIVERSITY OF DENVER,

BY HERBERT A. HOWE.

1894 Local M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Nov. 29 8 18 50	1	10, 10	−1 31.55	+1 40.2			9.394	0.813
Dec. 15 7 10 53	2	10, 10	+0 11.44	−2 27.2	23 29 6.09	−4 36 10.2	9.194	0.784
17 7 13 16	3		0.00	0.0			9.218	0.779
8 3 36	3	10, 10	+0 5.33	+0 40.1	23 34 37.07	−3 55 8.8	9.404	0.775
18 7 40 12	4	10, 10	+0 1.75	−3 1.2			9.334	0.775
19 7 54 7	5	14, 10	−2 33.41	+5 43.2	23 39 59.03	−3 15 2.0	9.383	0.771
20 6 50 55	6	20, 10	+0 3.23	−2 49.4			9.115	0.772
21 6 37 58	7	10, 10	+0 0.72	+2 43.7	23 45 10.78	−2 36 23.3	9.034	0.770
22 6 49 49	8	15, 10	−0 26.50	−1 44.3	. . . .	. . . .	9.124	0.767
25 6 48 11	9	5	. . .	−1 50.1	. . . .	. . . .	9.238	0.759
7 7 33	9	2,	+0 18.19					

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	22 45 42	+3.01	−10 7.7	+14.0	SDM. 10°6003.
2	23 28 51.66	+3.00	− 4 34 0.4	+17.4	Comp. with Argent. G.C. 31837
3	23 34 28.80	+3.00	− 3 56 6.4	+17.8	11ᴹ comp. with Washington star of Dec. 17.
4	23 37 11	+3.00	− 3 33.5	+17.9	11ᴹ Anon.
5	23 42 29.40	+3.01	− 3 21 3.4	+18.2	Argent. G.C. 32147 and Yarnall 10782
6	23 42 24	+2.99	− 2 54.3	+18.2	SDM. 3°5706
7	23 45 7.07	+2.99	− 2 39 25.4	+18.4	SDM. 2°6047 comp. with A.G.C. 32259
8	23 48 17	+2.99	− 2 16.6	+18.5	SDM. 2°6056
9	23 55 28	+3.00	− 1 16.3	+19.0	10½ᴹ Anon.

ORBIT OF COMET *e* 1894,

BY S. C. CHANDLER.

This comet presents unusual difficulty in the attempt to determine its form directly from the observations. Indeed, the eccentricity is practically indeterminate, even a parabola sufficing to represent the whole observed path tolerably well. The following elements have been obtained by varying the ratio of the distances and the major axis; but the adopted value of the latter is extremely uncertain. I have not thought it worth while to carry the approximation further until more observations are at hand. Unless these are obtained by the larger telescopes, after the present moon is out of the way, the comet's theory must remain in a very imperfect condition.

ELEMENTS.

$$T = 1894 \text{ Oct. } 12.4365 \text{ Greenw. M.T.}$$

$$\left.\begin{aligned} \omega &= 296^\circ\ 46'\ 50''.7 \\ \Omega &= 48\ \ 45\ \ 57.4 \\ i &= 2\ \ 57\ \ 55.1 \end{aligned}\right\} 1894.0$$

$$\log q = 0.143725$$

$$e = 0.56975$$

COORDINATES FOR THE EQUATOR.

$$\left.\begin{aligned} x &= [9.999671]\, r \sin(\ 75^\circ\ 30'\ 31''.1 + v) \\ y &= [9.955892]\, r \sin(346\ \ 34\ \ \ 2.4 + v) \\ z &= [9.633979]\, r \sin(340\ \ 49\ \ 36.0 + v) \end{aligned}\right\} 1894.0$$

$$\left.\begin{aligned} x &= [9.999670]\, r \sin(\ 75^\circ\ 31'\ 21''.3 + v) \\ y &= [9.955893]\, r \sin(346\ \ 34\ \ 53.3 + v) \\ z &= [9.633971]\, r \sin(340\ \ 50\ \ 22.2 + v) \end{aligned}\right\} 1895.0$$

Following is a comparison with all the observations which have come to hand, excepting one or two designated by the observer as uncertain. A few corrections have been applied to the star-places as originally published.

Date 1894	O—C $\Delta\alpha$	O—C $\Delta\delta$	Observer	Place
	s	″		
Nov. 21	+0.01	+ 5.1	Barnard,	Mt. Hamilton
22	−0.15	− 2.3	"	" "
23	−0.27	− 5.3	"	" "
25	−1.01	− 7.9	Bigourdan,	Paris
28	−0.45	− 0.1	Searle	Wash. Cath. Univ.
28	−0.03	+ 6.2	Barnard,	Mt. Hamilton
30	−0.67	− 8.9	"	" "

Date 1894	O—C Δα	O—C Δδ	Observer	Place
	s	″		
Dec. 1	−0.44	+5.3	Kobold,	Strassburg
2	−0.19	−1.6	Palisa,	Vienna
14	−0.30	+1.0	Wilson,	Northfield
15	−0.65	+8.2	Howe,	Denver
17	−0.13	−5.9	Brown,	Wash. Naval Obs.
17	−1.07	−2.0	Howe,	Denver
18	−0.26	−2.8	Wilson,	Northfield
Dec. 19	−0.66	− 8.4	Stone,	Charlottesville
19	−0.73	+ 4.0	Howe,	Denver
21	−0.93	− 3.6	"	"
21	+0.40	− 3.7	Wilson,	Northfield
27	−0.13	−10.8	"	"
28	+1.11	− 4.7	"	"

OBSERVATIONS OF COMET *e* 1894,

MADE AT THE GOODSELL OBSERVATORY, NORTHFIELD, MINN., WITH THE 16-INCH REFRACTOR AND FILAR MICROMETER,

BY H. C. WILSON.

1894 Northfield M.T.	∗	No. Comp.	☄ — ∗ Δα	☄ — ∗ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Dec. 14 6 17 1	1	6 , 6	−1 52.75	+0 52.5	23 26 11.33	−4 58 0.8	8.677	0.825
18 9 0 43	2	8 ,4	+3 55.60	−2 28.8	23 37 20.56	−3 34 55.2	9.501	0.807
21 9 36 47	3	10 ,6	−0 20.05	−3 21.9	23 45 26.52	−2 34 34.8	9.556	0.800
24 10 8 11	5	6 ,3	−4 9.44	−5 56.4	23 53 24.70	−1 34 37.4	9.590	0.794
27 7 9 41	6	9 , 5	−0 11.01	−4 8.2	0 0 56.92	−0 39 8.1	9.229	0.795
28 7 48 35	8	8 , 6	+1 20.21	+4 43.4	0 3 35.93	−0 19 35.1	9.370	0.792

Mean Places for 1894.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	23 28 1.08	+3.00	−4 59 10.6	+17.3	Karlsruhe (1885.0) and Argent. G.C. 31878
2	23 33 22.01	+2.95	−3 32 44.0	+17.6	Lal. 46315,6
3	23 45 43.58	+2.99	−2 31 31.3	+18.4	Micrometer comparison with ∗4
4	23 49 12.76	+3.01	−2 32 9.8	+18.5	Argent. G.C. 32259
5	23 57 31.13	+3.01	−1 29 0.1	+19.1	Brussels 10774
6	0 1 4.92	+3.01	−0 35 19.3	+19.4	Micrometer comparison with ∗7
7	0 0 42.20	+3.01	−0 28 6.0	+19.4	Schjellerup 9991–2
8	0 2 12.71	+3.01	−0 24 38.1	+19.5	Micrometer comparison with ∗9
9	0 2 23.64	+3.01	−0 27 30.8	+19.5	Schjellerup 6

The comet was exceedingly faint in all of these observations, but on Dec. 24 was especially difficult to observe. It was lost in thin haze before the observation was complete on that date, and but little weight should be given to the resulting position.

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THE NEW DUDLEY OBSERVATORY,

By LEWIS BOSS.

Arrangements for rebuilding the Dudley Observatory, at Albany, on a new site, were perfected nearly three years ago. The new buildings were nearly prepared for occupancy during the summer of 1893, though the instruments were not mounted until near the close of that year, nor arranged for regular observation until still later. The former location was abandoned in June, 1893.

A brief statement in regard to this new establishment, which has been nurtured to the present time by the generosity of private endeavor, may be not devoid of interest.

The disadvantages of the former location of the Dudley Observatory near a great railroad which skirted the hill at a distance of about 150 meters, the practical inaccessibility of the site, and the need for extensive repairs and alterations in buildings and instruments, had long been recognized. It was considered by all concerned that removal to a new site might result in advantages which would fully justify the expenditure. The decisive impulse came, however, in April, 1892, with the offer by Miss Catherine W. Bruce of New York City, to give $25,000 for additional endowment of the institution on condition that the "friends and neighbors of the Observatory" should secure its removal to a new and better site. This condition was promptly met, and the promised endowment was at once placed in the hands of the Trustees. In 1893 Miss Bruce assisted the Observatory with a further contribution of $10,000, of which a part will be carried to the credit of the endowment fund. To defray the cost of the new Observatory, contributions amounting to $24,123 have been received from sixty-five individuals, nearly all of whom are residents of Albany. The city of Albany gave land for the new site and $15,000 in exchange for the former grounds and buildings of the Observatory.

Miss Bruce and the other contributors fully understood that their assistance was intended to be used purely in the interests of scientific investigation, and they desired this. Their liberality affords another illustration of the manner in which private endeavor hastens to the support of scientific research in a country where the higher utility of such work is either ignored by the government, or is very imperfectly understood.

The new location of the Dudley Observatory is in the western part of Albany. The new dome is 2478 m. west, and 1134 m. south of the point to which the longitude of the old Observatory was referred:

$$\Delta\lambda = +7^s.25; \quad \Delta\varphi = -36''.7$$

It is probable that the adopted longitude of the old Observatory is too small by a large fraction of a second, as indicated by preliminary reductions of a longitude-campaign undertaken by the Coast and Geodetic Survey, as part of the trans-continental chain some four years ago. The Observatory possesses no record of the two previous determinations of longitude: but the difference probably arises from failure in later years to correct the longitude of the reference station in New York City for the results of the new determinations in later years by means of the Atlantic cable. It is proposed to devote careful attention to the astronomical coordinates of the new Dudley Observatory in the future. For the present the adopted coordinates of the dome attached to the main building are:

$$\lambda = 4^h\ 55^m\ 7^s; \quad \varphi = 42°\ 39'\ 13''$$

The transit-circle is $0''.33$ south and $0^s.153$ east from the dome.

The water-table of the main building is 67.0 meters above mean tide; the corresponding altitude of the center of the Olcott meridian-circle is 69.5 meters, and of the intersection of the polar and declination axes of the Pruyn equatorial is 79.6 meters.

The tract belonging to the new Observatory contains six acres, and is surrounded by a larger area of about forty acres, which belongs to the city of Albany, and is designed to form part of the system of parks. The horizon is unobstructed for a zenith-distance of 86° or 87° on all sides, and, for the most part, to the true horizon. The city lies mainly to the eastward, — southward from the old Observatory. Thus an advantage has been gained in this respect. At present the southern meridian of the transit-circle passes over the open country, and the nearest houses to the north are 400 meters distant.

The main, or office building, is situated 90 meters from a suburban street known as Lake Avenue. This building is of brick. Its length is 20.7 meters, width 10.7 meters. It is two stories in height, with a high attic. The architecture is Romanesque, of a pleasing, though simple style. The tower for the equatorial is attached to the western corner,—the azimuth of the front of this building being S. 38° 3′ W., parallel with Lake Avenue. The prevailing winds in clear weather are from the west. The dome is 6.4 meters in diameter; the center of the equatorial is only about one meter higher than the ridge of the roof of the office building. This building contains a room 9 m. by 5 m. for the library, the director's office, a convenient and well lighted computing-room, an interior room for the clocks, and two small rooms for the janitor. On the second floor are lodging rooms for the assistants, a well-lighted laboratory, and a computing room. Connected with this building by a corridor to the northward is the dwelling for the astronomer, built in a style similar to the Observatory.

To the eastward of the main building, 53 meters distant from the dome, is the Transit-Circle house. This building measures 7.3 meters from north to south, and 6.7 meters from east to west. The instrument is 0.3 m. to the north of the center of the building. The collimator piers are placed in small extensions to the north and south of the principal room. The framework of this building is of iron, very strongly made, and securely anchored to the stone foundation. This framework is covered on the inside with corrugated, galvanized iron, on the outside with wooden louvre-work, bolted on in panels, to facilitate removal for repairs. Between the coverings is an air-space of about 0.15 m. The ridge of the roof is in the meridian, and the roof is constructed in six sections, three on each side. These sections, by a simple mechanism, may be drawn away from the meridian on each side, leaving an open space for observation of any desired width up to 1.7 meters. At the same time the space at the top of the side and gable walls, always open for ventilation, is increased. When closed the sections are securely locked together by a simple device. Convenient means for adjusting the junction of the sections at any time are provided; but, thus far, owing to the accurate construction and rigidity of the framework, it has not been necessary to make use of this device. The outside covering of the roof is of wood, with a well-ventilated air-space between it and the inside lining of corrugated iron. This roof has proved to be absolutely weather-tight, and perfectly secure in the strongest gales we have experienced. It is operated quickly, and with less expenditure of force than is usually required for shutters alone.

The mass of the great piers, clothed in felt and wood, affects the temperature of the room somewhat during periods of rapid change, but the difference of temperature between this room and a carefully exposed external thermometer rarely amounts to 1° C., even when the room remains closed all day.

The Transit-Circle is the same that was provided in 1857 for the old Observatory by the first director, Dr. B. A. Gould, and is known as the "Olcott Meridian-Circle." This new building was provided for by a special contribution from the three sons of the late Thomas W. Olcott, in honor of whom the circle was named. This instrument has been described in Vol. I of the Annals of the Dudley Observatory. A condensed description is contained in the introduction of the Albany Zone-Catalogue (*Catalog der Astronomischen Gesellschaft*). The construction of this instrument is of great excellence. The efficiency of a large Transit-Circle in differential observations of faint objects would be generally conceded. But when, as in this case, the aperture is 0.203 m., and the focal length 3.0 m., it might be regarded as too large for the best results in the more refined classes of observation. This surmise, appears, however, to rest on suspicion rather than upon demonstration.

Taking advantage of this opportunity some changes, principally in the accessories of the circle have been introduced. The old microscopes have been shortened, and provided with new objectives. The effective magnifying power of these new microscopes is 36 diameters, whereas it was formerly but 22 diameters. The ease and precision with which the circle readings can now be obtained is decidedly increased. Under good conditions the probable error of a single bisection, carefully made, is $\pm 0''.16$, or for the mean of four microscopes $\pm 0''.08$.

The entire instrument has been cleaned and relacquered. New transit and zenith-distance threads have been inserted, The intervals on each side from the central thread of the transit-reticule are, approximately, $30^s.1$, $24^s.4$, $20^s.1$, $17^s.6$, $15^s.0$, $7^s.9$, $5^s.0$ and $2^s.5$. There are threads at 45^s, not ordinarily used. The change from the former arrangement of equal intervals, with spaces which were multiples of the intervals, was made for the purpose of breaking up rhythm in the registry of transit, of securing a wider interval between groups for attending to the adjustment of the eyepiece and to the zenith-distance bisection, to make possible the recognition of groups on the chronograph-record in case of broken transits, and to facilitate observation by the eye-and-ear method.

The piers which support the pivots are great monoliths of hard limestone, which are wider than the diameter of the circle, and extend above them. The microscopes are inserted through holes perforated in the stone. This form of mounting seems to possess great advantages, if, indeed, it be not positively preferable to any other existing form. These piers are the same which were used at the old Observatory, but in order to accommodate them to the shortened microscopes, sections were removed from the corners to 2.2 m. from the top, 0.33 m. in width, and 0.27 m. in depth. The central part of the pier is of the original thickness, 0.6 m., from east to west. The foundation of the instrument was carried to a point 5 meters below the original surface, where a moist but compact blue clay was encountered. Borings of two meters deeper indicated that the stratum is homogeneous to that depth at least. The lowest foundation consists of a well-made bed of concrete, 3.5 m. in length, 3.0 m. in width, and 0.7 m. in thickness. The dimensions of the pier of heavy masonry above this are 2.5 m. by 1.8 m.; and there is a capstone 0.3 m. in thickness of the full dimensions of this foundation-pier, upon which the supporting piers rest. Upon the top of the concrete foundation around the pier is laid a drain of agricultural tile surrounded by broken bricks, sand and other material. This tile drain discharges into another which is carried off with a good fall, down the slope to the north. The collimator piers and the foundation walls of the building are drained in like manner. A wide space about all the piers and exterior walls is filled in with clean, sharp sand, for drainage purposes, and also as a protection against frost and surface vibrations. The piers are laid in Portland cement, and the surfaces below ground are heavily coated with the same. During a year, since the circle was mounted, its stability seems to have been all that could have been anticipated; but final judgement on this point must be reserved until tests of more thorough and perfect quality have been applied for a longer time.

The old collimators were much too small—aperture, 4.5 cm. Nevertheless, one of them has been retained for the north collimator-pier. On the southern pier is mounted an objective made by John A. Brashear of Allegheny. The free aperture of this is 21 cm., and the focal length is 89 meters. The pier at the principal focal plane of this objective, for the support of the meridian mark, has been constructed in a solid manner, and placed within a simple shed for protection from the weather. The mark itself is not yet fastened to the stone; a temporary substitute is used at present. This mire-objective is of good defining quality.

In remounting the circle, especial attention was given to the arrangement and adjustment of the tracks for the reversing and reflection carriages. These run through continuously from one collimator pier to the other. The instrument can be reversed with ease and safety within less than three minutes; though, as a matter of precaution, it is considered advisable to take more time at night, when the illumination of the room is dim. Thus it is really practicable, and now customary, to measure the collimation of this instrument by reversal, either on the *mire*, on the nadir, or upon stars. The results from the various methods, in comparison with that from opposing collimators, show satisfactory agreement; but no sufficiently rigid tests have been applied as yet. Reflection observations are possible to zenith-distance 56°.

Great care was exercised in the transportation of the Olcott meridian circle from the old to the new Observatory, and in its subsequent shipment to Cleveland, Ohio, to be cleaned and relacquered. In this latter shipment the circles were not included. Yet, as the road from the old observatory is extremely rough (not really a road at all), and as the packing may have been less skillfully accomplished than it should have been, some natural curiosity existed as to the possible effects of this transportation. Valuable information on this point has been afforded by the new investigation for division-correction and flexure of the circles, which is in progress. The flexure and division-correction of the circles were investigated in 1879. Referred to zenithal readings in the position in which the circles have been used, the following comparison results.

$$
\begin{array}{lrr}
\text{Circle A, (1879),} & -0''.32 \sin z & +0''.62 \cos z \\
\text{(1894).} & -0\ .27 \sin z & +0\ .63 \cos z \\
\text{Circle B. (1879),} & -0''.66 \sin z & +0''.60 \cos z \\
\text{(1894),} & -0\ .67 \sin z & +0\ .44 \cos z
\end{array}
$$

The later determination is far more complete, and is presumably, more accurate. The two flexure determinations for circle A may be considered as practically identical. The difference for circle B is larger than could fairly be attributed to errors in the determinations, and may indicate that this circle has undergone a very slight change of form, minutely disturbing the former distribution of weight. In a different form, the two determinations for circle B are.

$$
\begin{array}{ll}
\text{(1879),} & 0''.89 \sin(137''.7+z) \\
\text{(1894).} & 0\ .80 \sin(146\ .7+z)
\end{array}
$$

Evidently, if any shock has been suffered by this circle, the resulting change has been very slight. The subjoined table exhibits a comparison of the corresponding results for division-correction for what have been termed the standard graduations in this investigation. The results for 15° and 75° in 1894, are still subject to a slight revision. The corrections refer to the mean of four microscopes.

Division-Correction.

	Circle A.		Circle B.	
	1879	1894	1879	1894
°	″	″	″	″
0	0.00	0.00	0.00	0.00
15	+0.31	+0.30	+0.05	−0.04
30	+0.07	+0.03	+0.18	+0.10
45	+0.78	+0.60	+0.09	−0.02
60	+0.70	+0.44	+0.00	−0.09
75	+0.60	+0.44	+0.03	−0.06

The average probable error of the final results in 1879 is about ±0″.04, and, in 1894, ±0″.02. The nominal probable errors are smaller. The differences are manifestly systematic. For circle B, they are extremely uniform and could be explained simply by supposing that the graduations at 0° offer a slightly altered phase under the new microscopes. In linear measure upon the circle, the discrepancies for circle B in no case exceed 0.00025 mm. (0.00001 inch). For circle A, the discrepancies are larger, and are confined to the second octant. These discrepancies are, in fact, larger than can fairly be ascribed to the accidental errors of determination; though in linear measure on the circles they do not exceed 0.0006 mm. ($\frac{1}{40000}$ of an inch) in any case. Difference of phase under the new microscopes seems to offer the more likely explanation of the discrepancies; though for circle A there may have been a slight distortion in the form of the circle as the result of shock.

The Observatory has been provided with a new equatorial. The funds for this having been supplied by the sons of the late Robert H. Pruyn, formerly President of the Observatory trustees, it has been denominated the Pruyn Equatorial. The contract for this instrument, upon terms very liberal to the Observatory, was undertaken by Warner and Swasey of Cleveland, Ohio. Under this contract, the optical parts were furnished by John A. Brashear, of Allegheny. The clear aperture of the telescope is 31 cm; the focal length of the visual combination is 4.57 m. and of the photographic lenses about 4.1 m.

The pillar upon which the telescope rests is of cast iron in two sections. The lower section spreads rapidly at the base, which measures 1.5 m. by 1.0 m., and is 0.45 m. below the floor of the dome. This hollow iron pier is firmly anchored through the cap-stone to the brick pier below. The running mechanism of the dome, with triple conical wheels, was made by Warner and Swasey; the superstructure is of steel ribs and galvanized iron covering. This dome works with great ease, in singular contrast to the unmanageable turret of the old Observatory, and it has continued to be satisfactory up to the present, without requiring repairs, adjustment or alteration.

The construction of the objectives differs somewhat from the usual type. In both combinations the flint lens is placed in front. The crown lens is common to both. The inner surfaces have a much deeper curve than the outer. Each lens is mounted in its own separate cell. These cells are beautifully fitted and hold the respective lenses of the two combinations in perfect adjustment relative to each other. The advantages of this arrangement are, that the objectives may be taken apart and cleaned at any time with ease and safety, and the exchange of combination can be effected within a few minutes and without undue apprehension. When the exchange is made from visual to photographic combination a section of the tube 24 cm. in length is also removed. The tail-piece, the micrometer, the camera, the cell of the crown lens, and the section of tube previously mentioned, are each fastened in place expeditiously and firmly by a device similar to that employed in locking the breech of a Krupp gun, corresponding octants of the screw and nut having been removed, so that a turn of 45° suffices to clamp the piece firmly in place.

The objectives have been tested only in a casual way as yet. The definition and color of the visual combination seem to be excellent. The spherical aberration is inappreciable; dispersed light is notably absent. The latter point received special attention from Prof. C. S. Hastings of Yale University who designed the lenses. The result is a very dark field even in regions rich with stars. Thus very faint objects near bright stars are especially well seen. In the parts of the sky less exposed to sky-illumination from neighboring electric lamps, faint nebulas and comets are well shown. In a fine night (not very frequent in the Hudson River Valley), any object as bright as the thirteenth magnitude can be measured in position with wire-illumination of the micrometer. A few tests upon double stars indicate that the defining power of the telescope is fully up to the standard required for a telescope of this size. The photographic combination has received only an incidental preliminary test as yet. It is believed to be of good quality. The flint lens of this combination is of American manufacture; the glass is exceptionally free from color and other defects.

The tube of the telescope is of steel and is very stiff. No appreciable flexure can be predicated from the measurements thus far made. This promises great advantage for photographic work in the future. The ocular end of the tube is nearly 0.5 m. shorter than the objective end. The finder-telescope is of 8 cm. aperture and of excellent quality. There is also another telescope attached to the main tube carrying an excellent objective of 11.5 cm. aperture and 4 meters focal length. This is provided with a rough micrometer, with motions in two directions for shifting the cross-threads to a distance from the line of collimation. This is the guide-telescope, to be used in connection with photographic work.

The axes are provided with the coarse setting-circles now everywhere customary. The fine circle in hour-angle reads to 5^s, and in declination to $1'$. The obvious advantage of this is that short verniers may be employed; the whole of the vernier is seen at once without shifting the reading glasses; and the reading to $1'$, which is accurate enough for purposes of identification in ninety-nine cases out of a hundred, can be made with certainty at a glance, and with less danger of mistake than with a more complicated vernier. If more precise results are required, the readings can be made by estimation within probable errors of less than 1″.0 and 1″.5, as has been actually shown more than once in measures for position of the polar axis, and other instrumental errors. In these latter measures at various zenith-distances and hour-angles, gratifying proof of the accurate working of the instrument and of its bearing surfaces has been obtained. No inexplicable anomalies have appeared.

The clamps and slow motions of this telescope have received careful attention with good results. By an ingenious arrangement of sleeve gears the slow motion in hour-angle has been carried to the end of the declination-axis opposite the telescope. The lost motion is surprisingly small, and this clamp is as firm as that in declination. This is of great convenience in all classes of observation.

The counterpoise-weights on the declination-axis are three in number, and are threaded upon a large bronze screw which is itself, a sleeve upon the heavy steel rod in prolongation of the axis. The counterpoising of the telescope in all respects offers no difficulty whatever.

The driving clock has a rotary pendulum. It is placed within the cast-iron pier which supports the telescope. The driving worm engages in a complete wheel, protected from dust by a brass shield. Winding of the clock-weight appears to have no influence upon the going of the clock, which works well. Critical tests of this clock remain to be made.

The position-micrometer is of the general type usually provided by Warner and Swasey. It is illuminated by small incandescent lamps, from the side as well as the end. The fixed plate carries two sets of threads at right angles; the longitudinal threads, five in number, at intervals of about 8^s are for transits. The movable frame carries threads perpendicular to these. The micrometer-threads, and those parallel with them on the fixed plate, are arranged in pairs of width varying from 10″ to 57″. This arrangement facilitates differential comparisons of faint objects. Any object which can be steadily seen in dark field can be measured in position with illuminated wires with a fair degree of accuracy. By means of carbon rheostats the illumination can be regulated to any required degree of brightness with great nicety of gradation. Opposite the side lamp is a highly polished mirror; thus the longitudinal threads are illuminated from both sides. This arrangement is not readily practicable for the micrometer-threads. The micrometer screw is bolted to the movable frame and the head works upon this as a nut. The screw has about 20 threads to the centimeter and is 6.8 mm. in diameter. The approximate value of one revolution is 22″.85. So far as the examination has yet proceeded, there is no appreciable variation of this value through a range of 50 revolutions.

A chronograph by Warner and Swasey is in use with the Pruyn equatorial.

This telescope has been in active use since 1894 March 29, when the position-micrometer was received. In the interval from that time to 1894 Dec. 22, upwards of one hundred positions for comets and small planets have been obtained through the use of this telescope.

The Observatory has three astronomical clocks, all of which were in use at the old observatory for many years. The two clocks employed in observation are mounted upon massive piers in the small interior room provided for the purpose in the main building. This room was especially planned to secure uniformity of temperature, and appears to serve its purpose well. Very particular attention has been given to secure a rigid support for the pendulums, under the idea that this point is of the first importance. The use of mercury contacts for these clocks has been discarded. Platinum points, upon wires suspended by delicate springs, of which the suspension-points are at the same height as that of the pendulum, rest upon the latter alternately throughout its period of oscillation, except for an instant at the middle of the arc, when both points are held off by projecting pins, delicately adjusted by fine screws. This arrangement has worked well thus far. The effect upon the amplitude of oscillation appears to be minute if not inappreciable, and no disturbance of the rate has been detected.

The library is valuable, and has been growing, in spite of our inability to make adequate returns to the numerous institutions which have constantly favored this Observatory by sending their publications to enrich its library.

An Observatory like this, of limited material resources, cannot promise an elaborate programme of work. It may be proper to state, however, that the logic of events and inclination invites this Observatory to undertake the comprehensive observation and discussion of stars known to have sensible proper motion. In this connection our warmest acknowledgements are due to the Board of Directors of the Bache fund of the National Academy of Sciences, which has granted two successive appropriations of $1000 each in aid of the preliminary work upon the stars having proper motion. For the past three years I have given much time and study to the collation of material and to computations as a foundation for the proposed discussion. An independent determination, by observations with our transit-circle, of the positions of the principal stars has been virtually decided upon as likely to afford a desirable basis in part for the proposed observations of the stars with proper motion. The division and flexure-error investigation, now in progress, is designed as the first active step in this work. Work with the equatorial must necessarily remain subordinate to this laborious undertaking; though it is expected that our zealous young assistants will continue to give a good account of themselves in work with this instrument, so far as circumstances permit.

The removal of the Dudley Observatory to a better site, together with the improvement in equipment and substantial increase in resources for support, seems to assure for it a measureable certainty of permanent activity which, it must be confessed, it did not formerly enjoy. Though the means for support of astronomical work at the Dudley Observatory are still slender, it is quite certain, at least, that these means will be carefully conserved to the end for which they were intended — the promotion of astronomical investigation.

OBSERVATIONS OF COMET *e* 1894 (E. SWIFT),

This very faint comet was observed 1894 Dec. 31, by Prof. H. A. HOWE, at Denver, Colorado, and Dr. H. C. WILSON, at Northfield, Minn. Prof. HOWE's observation is

1894 Denver M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
			m s	′ ″	h m s	° ′ ″		
Dec. 31 6 42 15	10	5	. . . .	+4 15.1	. . .	+0 37 39.3	. . .	0.742
7 3 10	10	4	−0 4.33	. . .	0 11 19.14	. . .	9.255	. . .

Mean Place for 1894.0 of Comparison-Star.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
10	0 11 20.45	+3.02	+0 33 4.3	+19.9	Comp. with Weisse-Bessel O, 209

The comparison-star was $10\frac{1}{2}^{M}$, and preceded Bessel's by $3^{m}\,15^{s}.10$, at 1′ 38″.7 south.
Moonlight and a slight haze made the continuance of the observations impossible.

Dr. WILSON says that his observation should be given but little weight, owing to the extreme faintness of the comet.

1894 Northfield M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Dec. 31 8 34 31	10	8 , 3	−0 17.80	−2 49.4	0 11 24.50	+0 38 12.0	9.484	0.786

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
10	0 11 39.35	+2.95	+0 40 41.8	+19.6	Micrometer-comparison with *11
11	0 9 10.95	+2.95	+0 42 27.8	+19.6	Lalande 163

NOTE ON THE INVESTIGATIONS OF GONESSIAT UPON THE VARIATIONS OF LATITUDE OBSERVED AT LYONS,

BY S. C. CHANDLER.

In the *Bulletin Astronomique*, t. XI, pp. 241, 291, Mr. GONESSIAT has given the results of some very important researches on this subject, based upon his meridian-circle observations of fifteen circumpolar stars between 1885 and 1889. Their especial value consists in the fact that they cover an interval in which we have few other contemporaneous observations suitable for this purpose. He deduces a period of 431 days, with a coefficient of 0″.22. His eq. (17), referred to Greenwich, and expressed in our notation, is

$$\varphi-\varphi_0 = -0''.22 \cos(t-241\,0939)\ 0^\circ.85$$

As he remarks, there is here an exceedingly close agreement of the epoch, but a coefficient "which notably exceeds that found by Mr. CHANDLER."

I may be pardoned, perhaps, in the remark that, treating the results of his table of observed results on p. 298 in a similar way to that which I have used for all the other investigations on this subject, I find, from a least-squares solution, the formula

$$\varphi-\varphi_0 = -0''.175 \cos(t-241\,0936)\ 0^\circ.85$$

where the epoch is for the Greenwich meridian. But eq. (52), *A.J.* 322, gives

$$\varphi-\varphi_0 = -0''.174 \cos(t-241\,0942)\ 0^\circ.85$$

so that the accordance in the range, as well as in the epoch, leaves nothing to be desired. The process of deriving these results appears to me to be entirely unobjectionable. The above remarkable agreement is strong testimony to the precision of GONESSIAT's observations.

SUNSPOT OBSERVATIONS,

MADE AT PHILADELPHIA, PENNA., WITH A 4½-INCH REFRACTOR,

BY A. W. QUIMBY.

1894	Time	New Gps.	Total Gps.	Total Spots	Fac. Gps.	Def.
July 1	8	1	5	32	2	fair
2	7	3	7	36	4	fair
3	7	2	9	42	4	fair
4	7	2	8	38	4	fair
5	7	–	7	64	4	good
6	8	2	9	79	4	good
7	9	1	10	84	4	good
8	1	1	10	91	4	good
9	9	–	10	100	3	good
10	7	1	10	116	4	good
11	6	1	10	56	2	poor
12	8	1	10	60	4	poor
13	7	2	12	90	4	good
14	7	–	12	88	4	good
15	7	–	8	106	4	good
16	7	1	9	134	4	good
17	7	1	10	85	3	fair
18	7	1	8	176	3	good
19	7	–	8	85	3	fair
20	7	–	7	50	3	fair
21	7	–	7	54	3	fair
23	5	–	5	29	–	poor
24	10	2	6	34	2	fair
25	7	1	7	35	3	fair
26	7	–	5	27	2	fair
27	7	–	5	31	2	fair
28	8	–	5	9	2	fair
29	8	1	6	10	3	fair
30	7	–	5	14	4	fair
31	7	–	3	19	2	poor
Aug. 1	7	1	4	55	4	good
2	8	4	8	68	3	fair
3	8	–	7	65	4	fair
4	10	–	5	63	3	poor
5	9	–	5	112	3	good
6	9	–	4	54	3	fair
7	8	2	6	64	2	fair
8	7	1	7	67	3	fair
9	7	–	6	42	2	poor
10	1	–	5	26	2	poor
11	7	1	7	22	4	poor
13	3	2	9	40	4	fair
14	8	1	7	54	4	fair
15[1]	8	–	6	28	3	poor
16	8	–	6	56	3	fair
17	8	3	10	92	4	fair
18	3	–	5	59	3	poor
19	8	1	6	61	4	fair
20	2	–	6	41	3	poor
21	8		6	31	3	poor
22	8	–	6	27	2	fair
23	8	–	4	18	3	fair
24	8	–	4	8	3	good
25	8	–	1	1	3	good
26	8	3	3	10	3	good
27	8	–	3	10	2	poor
Aug. 28	6	–	2	6	2	poor
29	6	–	2	10	2	poor
30	2	1	3	27	2	fair
31	7	1	4	18	3	poor
Sept. 1	8	1	3	24	3	fair
2	8	1	4	36	2	fair
3	5	1	3	14	5	fair
4	8	–	3	12	2	poor
5	8	1	4	12	1	poor
6	4	6	8	16	3	fair
7	3	2	10	23	3	fair
8	2	1	11	70	3	good
9	8	–	8	53	3	fair
10	8	–	7	68	4	fair
11	8	–	7	76	2	fair
12	8	–	8	90	3	fair
13	8	1	5	59	3	fair
14	2	–	5	80	1	poor
15	9	1	6	93	4	fair
16	8	1	7	48	3	poor
17	9	–	5	24	1	poor
20	7	1	3	18	2	fair
21	8	1	4	21	4	fair
22	8	1	5	15	4	fair
23	8	1	6	14	4	fair
24	8	–	6	16	4	fair
25	8	–	5	15	5	fair
26	8	–	3	5	2	fair
27	8	1	2	2	1	poor
29	3	2	4	28	2	fair
30	5	–	6	20	3	poor
Oct. 1	9	–	6	40	3	fair
2	8	2	5	78	4	good
3	10	2	7	99	3	good
4	10	–	5	56	2	poor
5	10	3	10	168	4	good
6	9	–	8	159	4	fair
7	9	–	7	154	4	fair
8	9	–	7	132	4	fair
9	8		5	45	–	v.poor
10	8		4	98	3	poor
11	9		5	95	3	fair
12	8	1	6	100	3	fair
13	5	–	4	22	–	v.poor
14	9	–	6	62	3	fair
15	9	–	5	31	3	fair
16	9		3	13	3	poor
17	9		2	7	3	fair
18	9	7	7	13	4	fair
19	12	–	4	13	3	fair
20	12	1	5	35	4	fair
21	7	1	6	45	4	fair
22	9	1	6	23	4	poor
23	9	–	4	25	2	poor
24	8		3	5	–	v.poor
27	9	–	4	19	3	poor
Oct. 28	9	1	5	19	4	fair
29	4	–	7	21	3	fair
30	12	–	4	13	3	poor
31	1	–	6	17	3	fair
Nov. 1	8	–	4	17	3	fair
2	9	1	5	11	3	fair
3	10	4	9	17	2	fair
4	9	3	11	39	4	good
6	10	–	6	47	3	fair
7	11	–	5	43	4	fair
10[2]	8	2	6	43	2	fair
11	9	–	6	46	3	fair
12	9	1	6	30	3	fair
13	10	–	4	45	3	fair
15	9	–	6	18	4	fair
16	9	–	5	11	3	fair
17	8	–	2	2	–	v.poor
18	8	–	4	18	2	fair
19	12	1	4	13	1	poor
20	9	1	5	10	2	poor
21	12	–	4	10	1	poor
22	9	1	5	31	3	fair
24	11	–	5	38	2	fair
25	9	3	7	35	3	fair
26	9	–	4	19	3	poor
27	10	2	6	26	3	fair
28	9	–	4	20	2	poor
29	9	1	4	14	3	poor
30	10	–	1	7	–	v.poor
Dec. 3	10	7	10	68	3	fair
4	12	–	8	43	4	poor
5	11	1	11	70	3	poor
6	11	–	9	53	4	poor
7	10	–	8	65	3	fair
8	4	–	5	14	1	poor
10	9	–	5	26	2	poor
12	3	–	3	10	–	v.poor
13	8	–	2	26	1	poor
14	8	–	2	32	2	poor
15	2	1	3	39	2	poor
16	9	3	5	83	3	fair
17	9	–	3	60	3	fair
18	10	1	5	102	3	fair
19	12	–	4	132	1	good
20	12	1	5	84	1	fair
21	12	1	4	74	2	fair
22	12	–	4	99	2	fair
23	9	2	5	61	3	fair
24	9	–	5	32	2	fair
25	9	3	8	23	2	poor
26	10	1	6	12	3	poor
27	2	–	6	8	2	poor
28[1]	3	1	2	13	–	poor
29	10	–	4	10	–	poor
30	10	–	4	16	1	poor
31	9	2	6	14	3	poor

[1] Made with $2\frac{1}{8}$-inch astronomical objective, 36 inches focal length.

[2] Transit of *Mercury*.

EPHEMERIS OF COMET *e* 1894 (SWIFT),

From CHANDLER's Elliptic Elements in *A.J.* no. 333.

BY GEORGE E. WHITAKER.

Gr. Mean Mid.	App. α	App. δ	log Δ	log r
1895	h m s	° ′ ″		
Jan. 1.5	0 13 43.46	+0 55 35.9	0.16290	0.21505
2.5	16 16.59	+1 14 22.0		
3.5	18 49.20	+1 33 1.6		
4.5	21 21.29	+1 51 34.6		
5.5	23 52.86	+2 10 0.8	0.17775	0.22080
6.5	26 23.92	+2 28 20.3		
7.5	28 51.48	+2 46 32.9		
8.5	31 24.54	+3 4 38.4		
9.5	33 54.10	+3 22 36.8	0.19248	0.22660
10.5	36 23.17	+3 40 28.0		
11.5	38 51.75	+3 58 11.9		
12.5	41 19.86	+4 15 48.6		
13.5	43 47.51	+4 33 17.9	0.20714	0.23246
14.5	46 14.71	+4 50 39.8		
15.5	48 41.47	+5 7 54.3		
16.5	51 7.80	+5 25 1.4		
17.5	53 33.70	+5 42 1.0	0.22164	0.23835
18.5	0 55 59.18	+5 58 53.1		
Jan. 19.5	0 58 24.25	+6 15 37.8		
20.5	1 0 48.93	+6 32 15.0		
21.5	3 13.22	+6 48 44.6	0.23596	0.24426
22.5	5 37.13	+7 5 6.7		
23.5	8 0.67	+7 21 21.1		
24.5	10 23.85	+7 37 27.9		
25.5	12 46.67	+7 53 27.0	0.25011	0.25019
26.5	15 9.14	+8 9 18.5		
27.5	17 31.27	+8 25 2.2		
28.5	19 53.05	+8 40 38.2		
29.5	22 14.50	+8 56 6.4	0.26403	0.25612
30.5	24 35.61	+9 11 26.8		
Jan. 31.5	26 56.39	+9 26 39.4		
Feb. 1.5	29 16.84	+9 41 44.2		
Feb. 2.5	1 31 36.98	+9 56 41.1	0.27773	0.26204

The relative brightness, 0.37, January 1, becomes 0.18, February 2.

Somerville, Mass., 1895 *Jan.* 10.

NEW ASTEROIDS.

Prof. KREUTZ communicates the discovery of another small planet by Mr. CHARLOIS.

BN 12^M Dec. 28 $11^h\ 29^m.5$ Nice M.T. $\alpha = 7^h\ 31^m\ 8^s$. $\delta = +20°\ 25'$ Daily motion, -60^s in α, and 3′ southward.

The designation 1894 *BO* has been given to a planet, 13^M, found upon a photograph of the nebula N.G.C. 4900, taken by Mr. ROBERTS 1894 April 9 (see *Monthly Notices*, R. Ast. Soc., LV. 14). Its position was

April 9 12^h Greenw. M.T. $\alpha = 12^h\ 59^m\ 8^s$. $\delta = +3°\ 8'$.

NEW ASTRONOMICAL WORKS.

Cordoba Durchmusterung, Part II. *Brightness and Position of Every Fixed Star, down to the Tenth Magnitude, between 32° and 42° of South Declination.* JOHN M. THOME, Director.

This second part of the important undertaking, carried on at the Argentine National Observatory during the years 1885 to 1893, has recently been published as Vol. XVII of the Results of the Observatory. A notice of the publication of the first part, containing the stars in the belt between 22° and 32° of south declination, appeared in no. 299 of this Journal. The present half of the work contains the positions and magnitudes of 160415 stars, making a total of 340215, and extends the census of the starry heavens to the tract comprised within 132° from the north pole. It is earnestly to be hoped that the undertaking may soon be pushed yet further south.

With this volume is given an atlas of twelve maps, drawn upon the same scale as the analogous ones of ARGELANDER and SCHÖNFELD, although the much greater number of stars plotted gives a more crowded aspect to the charts.

As in the former volume, tables are given showing the number of stars observed, in each degree of declination, for intervals of four minutes each in right-ascension. A count of the number of stars of each magnitude as far as 10^M would, even if only made by hours, afford a valuable supplement to this useful work.

Another extended list is also given by Dr. THOME, of those stars for which notable discordances were found in the estimates of magnitude, thus giving rise to suspicion of variability.

Publicationen der von Kuffner'schen Sternwarte in Wien, heraus gegeben von Dr. LEO DE BALL, *Director der Sternwarte.* III Band 1894.

The first division of this third volume contains 89 series of zone-observations of stars between 5° 50′ and 10° 10′ of south declination, made by Dr. DE BALL himself with the 4½-inch Repsold meridian-circle, essentially on the plan of those of the *Astronomische Gesellschaft*. They comprise stars to the ninth magnitude, and the probable error of a single observation has been found to be $\pm 0^s.036$ and $\pm 0''.49$.

The transits over the several threads are given, and the individual microscope-readings, together with all the data for computing the observations, and finally the resultant positions referred to the mean equinox of 1900.

These are followed by an elaborate memoir containing the results of measurement of photographic impressions of the cluster Herschel G. Catal. 1166 = M. 36, by Dr. S. OPPENHEIM. Three plates were used, taken 1892 March 20 and Sept. 19, and 1893 April 10; and from these the positions of 204 stars have been measured, and elaborated with great care and minuteness.

The second division of the volume consists of memoirs on subjects of general scientific interest.

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NEW ASTEROIDS.
NEW ASTRONOMICAL WORKS.

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ASTRONOMICAL JOURNAL.

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OBSERVATIONS OF THE TRANSITS OF *MERCURY*, 1891 MAY 9, AND 1894 NOVEMBER 9–10,

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY,

By E. E. BARNARD.

The transits of *Mercury* 1891 May 9 and 1894 Nov. 9-10, were both observed with the 12-inch equatorial. In the observations of these transits, I have endeavored to secure the best possible measures of the diameter of *Mercury* and of its position on the sun's disc.

The observations have in both cases been made with the Clark micrometer, of the screw of which one revolution = 14″.059 ±0″.0024. This value has been used in all the reductions. In the observations of 1894, two sets of diameters and one set of positions, were measured with a micrometer by Warner and Swasey, which is supplied, besides the ordinary spider-threads, with coarse platinum wires for the measures of faint diffused objects. Because of the presence in the field of these wires, it was thought that they might more or less influence the measures, and as it only permitted the use of low powers, the Clark micrometer was substituted for it in the remainder of the work.

In determining the diameter of *Mercury*, on both occasions, I have divided the measures equally between the diameters, in right-ascension and in declination, to try to detect any polar flattening of the disc. In both cases the results have indicated a slightly larger "equatorial" diameter. The difference is very small, and if real would indicate a very slight polar compression. I would not at all insist that this difference is real, and would rather look upon the coincidence as accidental. Nevertheless, the results may be of great importance in the future, as bearing upon the rotation of the planet on its axis in a reasonably short period.

They respectively indicate a polar compression of $\frac{1}{134}$ and $\frac{1}{98}$, or adopting a mean

$$\text{Polar Compression} = \tfrac{1}{116}.$$

Even though this result should be real, the unknown position and inclination of the axis of rotation would make it a minimum value.

The conditions for observation in 1894 were superior to those of 1891, though the planet was some 35° farther south.

The occurrence of the transit in the forenoon was of itself a great advantage, because the seeing is invariably better here in the first half of the day. On this particular day it happened to be unusually good.

In the measures of the diameter of a planet in transit with a good telescope, the steadiness of the atmosphere is, I think, a far more important factor than almost anything else. If we look at the planets on the dark sky when the seeing is bad, they appear larger than they would if the air were steady. Measures under such conditions would give a diameter greater than the real one, due to the spreading of the bright image by the unsteady air. In the case of *Mercury* or *Venus* in transit, poor seeing would have exactly the reverse effect. The image would be smaller than with good definition, because of the encroachment of the bright disturbed background upon the image of the planet. Or, in other words, irradiation is more effective the poorer the seeing. There is no doubt however, but that several other things enter into consideration. The density of the sun-cap, the magnifying power, aperture of the telescope, etc.; each and all are elements in fixing the apparent size of a planet in transit.

In the measures of 1891 the seeing was rather poor; but in those of 1894 the atmosphere was unusually steady, and the measures are consequently much more reliable.

In *A.N.* 3034 Dr. L. Ambronn has given a collection of the measures of *Mercury's* diameter, from 1832 to 1890. Of these results, 18 were measures made during transit by 17 different observers. Six of these were with some form of double-image micrometer, and twelve with the filar micrometer or other similar means. I have taken the means of the different results and they give for the diameter of *Mercury* at distance unity

In transit (double-image micrometer)	6″.505.
In transit (filar micrometer)	6 .340.

There are also three determinations on the sky, one of which is abnormal, and I shall reject it. The other two give

On the sky (double-image micrometer) 6″.601.

The accordance of these three separate results is certainly very satisfactory. Their mean, weighted according to the number of observations, is 6″.415.

This result, depending upon the work of 19 different astronomers extending through 58 years, may be taken as fairly representing the diameter of *Mercury* at distance unity.

In these observations the extreme range is 1″.3, *i.e.* from 5″.65 (Maclear, 1868) to 6″.94 (Carpenter, 1878), the mean of which (6″.29) deviates only about one-tenth of a second from the mean of all.

Following are the

Observations of the Transit of 1891 May 9.

Though the day was perfectly clear the atmosphere was very unsteady, the seeing varying from 1 to 3 on a scale of 5. The aperture of the 12-inch, was cut down to four inches, and this was used throughout the observations.

A careful search for the planet was made until five minutes before first contact with varying density of "sun-wedge," but no trace of it could be seen until first contact, and no trace of that portion of it off the sun could be seen between first and second contacts. During transit no ring of light could be seen about *Mercury*, nor could any markings be made out on its disc. A careful search for a satellite was also made.

The planet could not be seen with the unaided eye protected with a dark glass.

The following measures have been carefully reduced anew for this paper.

1891 *May* 9.

Standard Pacific Time of Contact.

	h	m	s	
I	3	53	7.0	
II	3	57	54.2	geometrical

Contact I was marked "2 seconds late," that is, it was seen for two seconds before certain identification. This correction has been applied to the above value of the first contact.

Measures of the Diameter of Mercury.

1891 *May* 9.

"Equatorial" (Right-Ascension) Diameter.

″		
10.81	(5 obs.)	150 diameters
10.57	(3 obs.)	175 "
11.25	(3 obs.)	500 "
10.877	(11 obs.)	5h 6m Stand. Pac. Time

"Polar" (Declination) Diameter.

″		
10.76	(5 obs.)	150 diameters
10.71	(3 obs.)	175 "
10.92	(3 obs.)	500 "
10.797	(11 obs.)	4h 45m Stand. Pac. Time

Reduced to distance unity, these become

Equatorial diameter	6″.065
Polar "	6 .020

Measures of the Position of Mercury.

1891 *May* 9.

Distances between center of *Mercury* and nearest (s.f.) limb of the *Sun*.

	Stand. Pac. Time h m s	″	
	5 6 54	142.73	To these has been added a refraction-correction of 0″.11
	5 9 22	145.74	
	5 11 10	147.36	
	5 12 32	150.11	Mag. power = 150 diameters
Mean	5 10 0	146.48	

Position-angle of threads in these measures = 46°.0.

h m s	″	
5 46 46	185.77	To these has been added a refraction-correction of 0″.58
5 48 19	187.08	
5 49 41	186.70	
5 52 40	190.05	Mag. power = 150 diameters
5 49 21	187.40	

Position-angle of threads in these measures = 54°.0.

h m s	″	
6 6 18	196.70	To these has been added a refraction-correction of 0″.72
6 8 23	195.73	
6 9 32	196.50	Mag. power = 150 diameters
6 8 4	196.31	

Position-angles of threads in these measures = 58°.7.

In the distances the nearest limb of *Mercury* and the nearest limb of the *Sun* were bisected. To the measures has been added 5″.42, the apparent semi-diameter of *Mercury* from my observations.

Observations of the Transit of 1894 November 9–10.

In these observations the seeing was very good, ranging from 3 to 5. The planet could not be seen before entering on the *Sun*. No ring of light was visible at any time. No spots or markings were seen upon its disc. The planet was sensibly lighter than the sky outside the *Sun's* disc, as tested by laying a micrometer-wire over the planet. The wire seemed to be about twice as black as *Mercury*, but was only slightly contrasted with the sky.

An endeavor was made to see *Mercury* with the eye, using a dark glass alone, but it could not be seen. It was however, very easily seen with a small terrestrial telescope of 1.38 inches diameter and 5 inches focus, which magnified 2¼ times. This small instrument belongs to Mr. Charles Burckhalter of the Chabot Observatory, Oakland, California. and was kindly loaned for the purpose. With this glass Mr. Burckhalter had seen the planet at the transit of 1891. Therefore, though *Mercury* cannot be seen at transits with the eye alone, it only requires a power not exceeding 2¼ diameters to make it easily visible.

A careful search with low and high powers, was made several times during the best seeing, for any possible satellite.

In the measures of the positions of *Mercury*, the center of the planet was bisected. The limbs were bisected by the wires in the diameter measures in both the observations of 1891 and 1894.

Standard Pacific Time of Contacts, 1894.

(Aperture 6 inches ; power 150.)

			h	m	s	
I	Nov.	9	19	57	9.1	Good, possibly 2ˢ late
II		9	19	58	42.3	Good (geometrical)

(Aperture 5 inches ; power 175).

			h	m	s	
III	Nov.	10	1	11	36.6	Good (geometrical)
IV		10	1	13	16.3	Good

For I, at the recorded time above, there was the slightest indentation of the limb of the *Sun*, which was estimated to be equal to about 2 seconds of time — this correction has *not* been applied.

At II there was a slight black drop, which did not interfere with the contact, as it was faint; it lasted 9 seconds after geometrical contact.

All the observations were perfectly satisfactory. There was no black drop at contact III.

Measures of the Diameter of Mercury.

" Equatorial " (Right-Ascension) Diameter.

Stand. Pac. Time. h m	″		
8 20	9.15	(4 obs.)	500 diameters
9 5	8.99	(5 obs.)	175 diam.(W.&S.mic.)
9 50	9.35	(5 obs.)	500 diameters
9 55	9.59	(5 obs.)	500 "
11 32	9.18	(5 obs.)	500 "
12 30	9.17	(5 obs.)	500 "
Mean	9.237	(29 obs.)	

" Polar " (Declination) Diameter.

h m	″		
9 0	8.83	(5 obs.)	175 diam.(W.&S.mic.)
9 40	9.41	(5 obs.)	500 diameters
10 10	9.26	(4 obs.)	500 "
11 40	9.07	(5 obs.)	500 "
12 45	9.59	(5 obs.)	500 "
Mean	9.144	(24 obs.)	

Double-distance measures in each case.

These reduced to distance unity become

	″
" Equatorial " diameter	6.241
" Polar " "	6.178

The measures at 9ʰ 50ᵐ and 10ʰ 10ᵐ were made by bisecting the center of *Mercury* with one thread, and placing the other a half diameter (by estimation) beyond the limb.

Difference of Right-Ascension, Center of Mercury and fol. Limb of Sun, Mercury preceding.

Stand. Pac. Time.	h	m	s	″	
	8	8	12	67.61	
	8	9	41	74.74	
	8	10	40	79.70	
Mean	8	9	31	74.02	

Micrometer-threads reversed.

	h	m	s	″	
	8	11	37	85.07	
	8	12	28	90.39	
	8	13	20	94.80	Mag. power = 150 diameters
Mean	8	12	28	90.09	

These have been diminished by a refraction-correction of 0″.11

	h	m	s	″	
	8	26	50	168.14	
	8	27	58	174.11	
	8	28	41	178.63	
Mean	8	27	50	173.63	

Micrometer-threads reversed.

	h	m	s	″	
	8	30	25	186.92	
	8	31	10	191.97	
	8	31	50	196.62	Mag. power = 150 diameters
Mean	8	31	8	191.84	

These have been diminished by a refraction-correction of 0″.16

	h	m	s	″	
	9	6	8	381.14	
	9	7	12	388.33	
	9	7	58	391.39	
	9	8	41	395.71	
Mean	9	7	30	389.14	

Micrometer-threads reversed.

	h	m	s	″	
	9	10	32	403.80	
	9	11	23	408.72	
	9	11	59	412.38	
	9	12	43	416.76	Mag. power = 175 diameters
Mean	9	11	39	410.41	

These have been increased by a refraction-correction of 0″.20

Difference of Declination, Center of Mercury and North Limb of Sun, Mercury South.

	h	m	s	″	
	10	48	30	698.32	
	10	49	29	698.62	
	10	50	10	695.29	
	10	52	10	691.25	
	10	53	37	686.41	
	10	54	30	683.85	Mag. power = 150 or 175 diam.
Mean	10	51	24	692.29	

These have been increased by refraction-correction of 0″.49

	h	m	s	″	
	11	46	28	555.96	
	11	48	13	551.80	
	11	49	3	549.11	
	11	49	38	548.90	
	11	50	8	548.55	
	11	50	50	546.96	
	11	51	48	544.21	Mag. power = 150 diameters
Mean	11	49	27	549.37	

These have been increased by a refraction-correction of 0″.39

Difference of Right-Ascension, Center of Mercury and preceding Limb of Sun, Mercury following.

	h	m	s	″
	12	3	9	598.93
	12	4	29	590.84
	12	5	40	586.56
	12	6	14	582.69
	12	6	55	578.26
	12	7	34	575.18
	12	8	18	569.94
	12	8	57	567.24
	12	10	4	561.94
Mean	11	6	49	579.05

Mag. = 150 diameters

No refraction-correction applied to these.

Distance of Center of Mercury from nearest (n.p.) Limb of Sun.

	h	m	s	″
	12	50	15	126.57
	12	50	52	123.94
	12	51	36	119.64
	12	52	12	115.65
	12	52	47	112.26
Mean	12	51	32	119.61

Position-angle of threads during the measures = 43°.0. No refraction-correction.

In the right ascension and declination measures, the parallel was carefully determined before and during the observations, and checked at the close. Six inches aperture up to 11^h 20^m; after that 5 inches.

From 8^h 50^m to 9^h 35^m the Warner and Swasey micrometer was used. The value of a revolution of the screw of this micrometer is 22″.477 + 0″.002.

The observations throughout, in both transits, are in Standard Pacific Time, which is 8^h 0^m 0^s slow of Greenwich. Where required, I have applied corrections for refraction, as indicated.

ON THE VARIATIONS OF LATITUDE AT POULKOVO, FROM THE OLDER OBSERVATIONS WITH THE GREAT VERTICAL CIRCLE,

BY A. IVANOF.

1. In view of the importance of the question of the variation of latitude, and of the fact that Mr. CHANDLER, in examining the large number of old observations, has arrived at unexpected results, it seems to me that the examination of all observations which can give any information, one way or the other, should be regarded as imperative. In this regard the old observations, made in the formation of the catalogue, deserve the especial attention of astronomers, since they ordinarily embrace large intervals of time, and may give very useful and interesting results. In observing with the great vertical circle of Poulkovo, I have undertaken the examination of the two large series of old observations made with this instrument. One of these series served to form the catalogue of declinations of 1865.0, and the other for the catalogue of 1845.0. The results which I obtained are given in a series of articles as follows.

1. *Variations de la latitude de Poulkovo déduites des observations faites au grand cercle vertical dans les années* 1863–75 (*Mél. math. et astr., T. VII, livr.* 3, 1894).
2. *Variations de la latitude de Poulkovo déduites des observations faites au grand cercle vertical dans les années* 1842–49 (*Bull. de l'Acad. Imp. des Sciences*, 1894 *Septembre, N.* 1).
3. *Sur les lois des variations des latitudes terrestres d'après les observations faites au grand cercle vertical de Poulkovo* (*Bull. de l'Acad. Imp. des Sciences*, 1894 *N.* 3).

As to the results of these articles, it will perhaps be useful to reproduce here the epochs of maxima and minima These are

1863 to 1875		1842 to 1849	
Maxima	Minima	Maxima	Minima
1864.76	1864.09	1842.70	1842.33
65.87	65.32	43.72	43.14
67.08	66.53	44.54	44.17
68.35	67.81	45.71	45.19
69.53	68.92	46.80	46.27
70.74	70.12	47.72	47.33
71.94	71.35	1848.69	48.19
73.10	72.51		1849.09
74.28	73.65		
1875.38	1874.84		

I regard the results obtained by me to the present time as a first approximation in the research; because I have assured myself after deep reflection that the observations examined by me can give more than I have obtained.

Since I shall give a detailed exposition of the definitive results in the *Bulletin de l'Académie Imp. des Sciences de St. Pétersbourg*, I limit myself here to a shorter statement.

2. Let us direct our attention to the observations made from 1863 to 1875. I have examined first those of *Polaris*. These observations are suitable for finding the annual term as well as for that of 428 days.

I have combined in a single mean the declinations of *Polaris* obtained from the mean of the observations made in the same month of the different years. Then I have compared these monthly means with the mean value given in the catalogue of 1865.0, which is entirely free from the variations of latitude. I thus obtained the following values of the differences $\varphi-\varphi_0$.

	$\varphi-\varphi_0$	Wt.		$\varphi-\varphi_0$	Wt.
	″			″	
January	−0.08	8	July	0.00	39
February	−0.12	15	August	0.00	4
March	−0.07	58	September	+0.08	38
April	−0.03	78	October	+0.02	77
May	−0.02	67	November	+0.08	28
June	+0.07	45	December	+0.08	18

In forming this table I have used the observations of *Polaris* made at both culminations.

Assuming as the expression of the annual term the formula

$$\varphi-\varphi_0 = H_1 \sin(\odot+K_1)$$

I obtained by the method of least squares,

$$H_1 = 0''.06 \pm 0''.03 \quad , \quad K_1 = 291° \pm 24°$$

so that we can write

$$\text{(1)} \qquad \varphi-\varphi_0 = 0''.06 \sin(\odot+291°)$$

To obtain the 428-day term from the observations of *Polaris* I have compared the monthly values of the declination, already used above, with the observed values on the individual dates, and thus obtained a series of values of $\varphi-\varphi_0$. I then divided the whole interval of time from 1863 to 1875 into equal parts, each containing 14 months. The series of differences $\varphi-\varphi_0$, corresponding to each of these parts, were combined in a single series, which should determine the mean curve with the period of 428 days. This series is given below.

t	$\varphi-\varphi_0$	Wt.	t	$\varphi-\varphi_0$	Wt.
	″			″	
−0.29	+0.12	44	+0.29	−0.06	23
−0.21	−0.07	34	+0.37	−0.05	29
−0.13	−0.01	33	+0.45	+0.01	32
−0.04	−0.12	54	+0.54	+0.08	28
+0.04	−0.16	35	+0.62	+0.27	27
+0.12	−0.10	26	+0.71	+0.12	34
+0.20	−0.12	29	+0.79	+0.22	35

The argument t is expressed by the formula

$$t = T - 1870.0 + 1.18\,n$$

where T is the time of observation and n is the number of periods.

Putting for the 428-day term, the equation

$$\varphi-\varphi_0 = H \sin(\mu t+K) \; , \quad \text{where} \quad \mu = \frac{2\pi}{1.18}$$

I obtain

$$\text{(2)} \qquad \varphi-\varphi_0 = 0''.16 \sin(\mu t+241°)$$

3. After this. I tried to determine both the annual and the 428-day terms from all the observations between 1863 and 1875. To find the 428-day term I used the differences $\varphi-\varphi_0$ given in my first article on the variation of latitude at Poulkovo. I combined some of these in such a way as to get a single value of $\varphi-\varphi_0$ for each month. These values were then freed from the annual term by means of formula (1), which gave a new series for $\varphi-\varphi_0$ dependent only on the 428-day term. Then, dividing the whole interval, 1863 to 1875, into periods of 14 months, I proceeded as in the case of *Polaris*, obtaining the series of differences given below. It should be remarked that sensibly identical results would be obtained, if eq. (1) be slightly changed. or even if the effect of the annual term be not eliminated.

t	$\varphi-\varphi_0$	Wt.	t	$\varphi-\varphi_0$	Wt.
	″			″	
−0.29	+0.08	649	+0.29	−0.06	832
−0.21	+0.01	746	+0.37	−0.01	756
−0.13	−0.01	587	+0.45	+0.06	469
−0.04	−0.09	815	+0.54	+0.10	542
+0.04	−0.16	813	+0.62	+0.13	777
+0.12	−0.11	484	+0.71	+0.11	667
+0.20	−0.08	463	+0.79	+0.11	580

Employing these differences I found, by the graphical method. that the 428-day term is expressed by

$$\varphi-\varphi_0 = 0''.14 \sin(\mu t+241°) \qquad (3)$$

To determine the annual term from the total of the observations. I eliminated the effect of the 428-day term from the differences $\varphi-\varphi_0$ given in my first Memoir, by means of eq. (2), and combined in a single mean the values for the same month; which gives the following table.

	$\varphi-\varphi_0$	Wt.		$\varphi-\varphi_0$	Wt.
	″			″	
January	−0.07	200	July	+0.03	617
February	−0.07	616	August	+0.02	756
March	−0.02	1356	September	+0.04	777
April	+0.01	1129	October	+0.03	1194
May	+0.03	905	November	−0.01	620
June	+0.04	756	December	−0.04	530

Employing these differences, the graphical method gives, for the annual term.

$$\varphi-\varphi_0 = 0''.04 \sin(\odot+323°) \qquad (4)$$

I think that the angle 323°, which gives the epochs of maxima and minima, is well determined, but that the semi-amplitude 0″.04 is a little less than it really is, which is a not unexpected result.

4. Having regard to all that precedes, I conclude that, for the interval 1863–75, the differences between the instantaneous and mean latitude may be calculated with sufficient precision by the formula

$$\varphi-\varphi_0 = 0''.15 \sin(\mu t+241°) + 0''.04 \sin(\odot+323°) \qquad (5)$$

By means of the equation

$$\cos(\mu t+241°) = -0.31 \cos(\odot+323°)$$

which may be solved by approximation, I find the following times for maximum and minimum epochs.

Epochs	O—C y	Epochs	O—C y
1864.16	−0.07	1870.09	+0.03
64.74	+0.02	70.63	+0.11
65.32	0.00	71.23	+0.12
65.91	−0.04	71.81	+0.13
66.54	−0.01	72.43	+0.08
67.16	−0.10	73.04	+0.06
67.80	+0.01	73.62	+0.03
68.38	−0.03	74.28	0.00
68.96	−0.04	1874.76	+0.08
1869.52	+0.01		

In the column O—C I have placed the differences between the observed and calculated epochs. A glance will show the systematic character of these differences. This systematic character will disappear if we regard the value of K as variable. I have found that it varies according to the law

$$K = 241° + 47° \sin (T - 1867.0) \cdot 5° \tag{7}$$

where T is the time of observation. This equation is precise only for the interval considered. Thus, eq. (5), using the value of K expressed by eq. (7), is the definitive formula. Calculation now gives the epochs of maxima and minima following.

Epochs	O—C y	Epochs	O—C y
1864.13	−0.04	1870.12	0.00
64.71	+0.05	70.70	+0.04
65.30	+0.02	71.28	+0.07
65.90	−0.03	71.88	+0.06
66.53	0.00	72.51	0.00
67.16	−0.08	73.14	−0.04
67.81	0.00	73.68	−0.03
68.39	−0.04	74.37	−0.09
68.88	+0.04	1874.85	−0.01
1869.55	−0.02		

The mean departure of calculation from observations is two days.

5. We may now pass to the observations with the vertical circle made in the years 1842–49. I first found the 428-day term. To this end I chose only those stars observed, from 1842 to 1849, in the same months of the different years, and of which the mean declinations cannot be free from the effect of the annual term. I then formed for each month the differences between the instantaneous and mean latitude. Finally, by the graphical method, I found the following epochs of maxima and minima.

Minima	Maxima
1842.86	1843.37
43.90	44.41
44.97	45.70
46.16	46.79
47.46	1847.99
1848.65	

The mean value of the period is 1.16 years. To find the mean curve I obtained the following differences:

t	$\varphi-\varphi_0$ ″	Wt.	t	$\varphi-\varphi_0$ ″	Wt.
−0.46	+0.11	339	+0.13	0.00	269
−0.37	+0.05	336	+0.21	−0.10	388
−0.29	+0.01	459	+0.29	−0.08	439
−0.20	+0.06	137	+0.37	0.00	451
−0.12	−0.05	360	+0.46	−0.05	465
−0.04	−0.04	208	+0.54	+0.02	484
+0.04	+0.01	198	+0.62	+0.07	360

The equation of the mean curve, from these values, is

$$\varphi - \varphi_0 = 0''.08 \sin (\mu t + 255°) \tag{9}$$

To determine the annual term I employed the values of the differences given in my article "*Variations de la latitude de Poulkovo déduites des observations faites au grand cercle vertical dans les années* 1842–49." I freed these from the effects of the variations by means of eq. (9), obtaining the following table, which presents the annual variations.

	$\varphi-\varphi_0$ ″	Wt.		$\varphi-\varphi_0$ ″	Wt.
January	−0.09	125	July	+0.13	744
February	−0.14	255	August	+0.10	998
March	−0.12	1173	September	+0.13	865
April	−0.13	1082	October	+0.09	617
May	−0.04	1183	November	0.00	359
June	−0.02	972	December	−0.09	327

This series served to find the values of H_1 and K_1 in the equation

$$\varphi - \varphi_0 = H_1 \sin (\odot + K_1)$$

which represents the mean annual course. We find

$$H_1 = 0''.12 \quad \text{and} \quad K_1 = 274°,$$

so that

$$\varphi - \varphi_0 = 0''.12 \sin (\odot + 274°) \tag{10}$$

Thus, from 1842 to 1849, the differences between the instantaneous and mean latitude may be calculated from the formula

$$\varphi - \varphi_0 = 0''.08 \sin (\mu t + 255°) + 0''.12 \sin (\odot + 274°) \tag{11}$$

To calculate the epochs of maxima and minima we have

$$\cos (\odot + 274°) = -0.59 \cos (\mu t + 255°) \tag{12}$$

The epochs thus found agree very well with those observed; but the differences O—C again bear a systematic character, which disappears if we regard K_1 as variable. I find that it varies nearly according to the law

$$K_1 = 274° + 50° \sin (T - 1845.0) \cdot 5° \tag{13}$$

Consequently, eq. (11) should be changed, definitely, into the following:

$$\varphi - \varphi_0 = 0''.08 \sin [\mu (T - 1845.0) + 255°] + 0''.12 \sin (\odot + K_1) \tag{14}$$

where K_1 is expressed by eq. (13).

After all this I find the following epochs of maxima and minima.

Epochs	O—C	Epochs	O—C
1842.33	0″.00	1846.18	+0″.09
42.77	−0.03	46.73	+0.07
43.63	+0.09	47.24	+0.09
44.12	+0.05	47.77	−0.05
44.64	−0.10	48.26	−0.07
45.15	+0.04	48.77	−0.08
1845.68	+0.03	1849.20	−0.11

The mean departure of calculation from observation is one day.

6. In conclusion, I should say that the essence of the methods which I have employed is such that the epochs are very well determined, but that the semi-amplitudes are a little less than they are in reality. Taking this into account, it can be easily seen that my formulas (7), (9), (13) and (14) accord very well with the known formula (52) of Mr. CHANDLER.

If I have limited myself to the determination of the variations of K during the interval 1863–75, and of those of K_1 during the interval 1842–49, this is explained by the circumstance that, in using two isolated series of observations, it is difficult to determine the variations of all the quantities in Mr. CHANDLER's formula. I believe that all my researches on the variation of latitude are not without value; and that, as they confirm the very important investigations of Mr. CHANDLER, we cannot doubt at least some of the features of this curious phenomenon. Thus, there is no doubt that two periods subsist; one equal to 428 days, the other to a year. Also, the semi-amplitudes of both terms are variable beyond any doubt. From these two facts we may regard my researches as throwing some light on the enigmatic phenomena of the variation of terrestrial latitudes.

ON THE VARIABLE STAR 103 *T ANDROMEDAE*,

BY PAUL S. YENDELL.

During the past year I have looked for *T Andromedae* on fifty-two nights. Of these, four were in the winter and spring of 1894, and the remaining forty-eight extend over the period from 1894 May 29 to 1895 Jan. 14, inclusive, the longest interval between two observations being three weeks. The star was invisible in my telescope on October 7, and was first seen at the next observation, on October 18, when its brightness was estimated at $10^{M}.3$. From this date it was kept under as constant watch as circumstances permitted, and rose pretty rapidly and regularly to a maximum, which was passed on 1894 December 4, the highest observed magnitudes being $8^{M}.3$ and $8^{M}.2$. Its mean light at the maximum was about $8^{M}.5$; the decrease was slower than the increase, and at the last observation, on January 14, its light was $9^{M}.4$.

In No. 3213 of the *Astronomische Nachrichten*, Prof. E. C. PICKERING and Dr. HARTWIG have both published observations and given elements of variation for the star, which are contradicted by this series of observations. PICKERING gives nineteen observations, mostly from the H.C.O. photographs, and deduces from them a light-curve, giving residuals from comparison with the observations. No other comparison of observations with elements is given in his paper, though very fair approximations to the times of four maxima are deducible from the data there furnished.

HARTWIG's period of 74.4 days calls for maxima on 1894 June 25, Aug. 8, and October 21. The first two are barred by my observations of June 13 and July 3, and of August 5 and 10, — at all of which dates the star was invisible in my telescope, and cannot have been so bright as $11^{M}.0$; and on October 22 I observed it at $10^{M}.5$, it having been first seen only four days before. In addition to this, the observations from which my maximum is deduced extend over a space of more than eighty days. HARTWIG's observation of 1893 December 28 remains sharply discordant with the new elements, given later on in this paper, and very strongly suggests the possibility of a misidentification.

Upon the first appearance of PICKERING's paper, the implied claim of special accuracy for the elements struck me as not being well founded, in view of the fact that the observations could be equally well accounted for by a period of either about 265 or 293 days; but it seemed best to reserve criticism until it could be founded on a good determination of an actual maximum.

The thirty-four observations, on which my maximum above given depends, fix the date within very close limits of error, and since receiving by private letters from H. M. and J. A. PARKHURST observed dates of the same maximum, which with my own fall within a space of four days, I feel justified in considering that the error of my date is probably not more than a single day.

Using this date, and the indications of the last three residuals in the table of comparisons with PICKERING's elements, given below, I find the following elements, which account for all the inferred and observed dates, in a very satisfactory manner:

$$1855 \text{ Sept. } 10 \; (J.D.\, 2398837) + 265^{d}.35\, E$$

According to these elements, the next three maxima will occur on the following dates:

1895	August	24.25
1896	May	15.60
1897	February	4.95

A slightly longer period, say $265^{d}.39$, will satisfy the observed times of *E*54 more closely; but, considering that the date assumed as the principal epoch is subject to a few days' uncertainty it is not worth while to attempt further refinement until more data can be accumulated.

From the observations given by Pickering, *loc. cit.*, the first four of the following five dates of maximum were deduced by the use of the star's mean light-curve; the fifth is my own, stated above.

Observed Maxima.

Observed Time		Computed Time—Pickering		O—C	Computed Time—Yendell		O—C′
				d			d
1855 Sept. 10	Bonn	E1	1855 Oct. 11	−31.0	E0	1855 Oct. 10	0.0
1878 Dec. 5	Camb.	31	1878 Nov. 9	+26.0	32	1878 Dec. 9.2	−4.2
1892 Jan. 7	H.C.O	48	1891 Dec. 8	+30.0	50	1892 Jan. 6.5	+0.5
Sept. 25	"	49	1892 Sept. 14	+11.0	51	1892 Sept. 26.9	−1.9
1894 Dec. 4	Y.	52	1895 Jan. 5	−32.0	54	1894 Dec. 1.9	+2.1

A glance at the residuals in the column O—C of the above table is instructive. As they stand, they are intolerable. They indicate that the small residuals, from comparisons of the H.C.O. photographs with Pickering's light-curve in the table below, are illusory. And the last three, extending over a space of five consecutive epochs, give clear indication that the period, from a comparison with which they were deduced, is too long by an average amount of about 15.5 days.

The subjoined table gives, in the column O—C, the comparisons of the observations collected by Pickering, with his light-curve, and in the column O—C′, with the actual curve as shown by the observations. For compactness' sake, only the cases where the star was actually seen have been used. Attention is particularly called to the fact that the observations of 1891 and that of 1893, which in Pickering's table show residuals of $0^{M}.0$ in 7 cases, and of $0^{M}.1$ in the remaining one, depart from the star's curve, as actually observed, by $1^{M}.2$ to $2^{M}.6$, — errors which, even with so red a star (6.0 of Chandler's scale) would be considered intolerable, if made by any one using the visual methods of observation.

Of the thirty-four observations of the star, from which my curve is drawn, the mean departure from the curve is about $0^{M}.12$, the extreme deviation being a single residual of $0^{M}.5$, from an observation depending on a single comparison-star, and marked as doubtful in the original entry.

The mean departure of the same observations from Pickering's curve is $0^{M}.52$, the difference of the last observation being about two magnitudes.

Comparison of Pickering's Collected Observations with the Two Light-Curves.

			O—C	O—C′
	M		M	M
1855 Sept. 7	9.0	Bonn	(+0.2)	+0.6
10	8.3	"	(−0.4)	−0.1
1878 Nov. 29	8.7	Camb. E.	(+0.4)	+0.1
Dec. 11	8.7	"	(−0.1)	+0.3
1891 Nov. 2	10.4	H.C.O.	0.0	−2.6
27	9.3	"	−0.1	−2.1
Dec. 13	9.2	"	0.0	−1.2
1892 Oct. 24	10.6	"	0.0	+0.1
Nov. 6	11.1	"	0.0	0.0
13	11.4	"	0.0	−0.1
1893 Sept. 13	12.3	"	0.0	−2.6
1894 Jan. 2	12.3	"	0.0	−0.9

The conclusion is, that Prof. Pickering, by using an erroneous period, and an assumed form of light-curve which is not only inherently improbable, but which actually proves to be incorrect, has secured a factitious agreement in the H.C.O. photographic magnitudes; also that these photographic magnitudes, instead of being correct to $0^{M}.0$ or $0^{M}.1$, have an average error of $1^{M}.2$.

Dorchester, Mass., 1895 *Jan.* 17.

NEW ASTRONOMICAL WORK.

Astronomische Chronologie, von Dr. Walter F. Wislicenus. Leipzig, B. G. Teubner, 1895, (5 marks).

A very convenient handbook, chiefly intended for the use of historians and archaeologists, but well adapted for employment by many astronomers.

It contains data for reciprocal conversion of dates according to various calendars; for the approximate determination of solar and lunar eclipses; the sun's longitude at different dates; the heliacal rising and setting of stars at given dates and places, etc.

A catalogue of auxiliary tables is given, with description of their contents, and directions for their use; also numerical examples for processes frequently required.

The work promises to be generally useful for cases in which the more extensive works of Ideler are ordinarily consulted.

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Observations of the Transits of Mercury, 1891 May 9, and 1894 November 9–10, by Prof. E. E. Barnard.
On the Variations of Latitude at Pulkowa, from the Older Observations with the Great Vertical Circle, by Mr. A. Ivanof.
On the Variable Star 103 *T* Andromedae, by Mr. Paul S. Yendell.
New Astronomical Work.

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ON THE PRINCIPAL FUNDAMENTAL CONSTANTS OF ASTRONOMY,

By SIMON NEWCOMB.

The following is a general account of some features and results of a work on which I have been engaged for the past fifteen or twenty years, consisting in a redetermination of the fundamental constants of astronomy, and of the elements of the orbits of the four inner planets. It is presented to the *Astronomical Journal* because it will be several years before the definitive investigation can be published, and even the printing and issue of a condensed preliminary discussion now in press may take several months.

The work has been prosecuted in the hope that a determination of the principal astronomical constants, founded on an investigation of all the more valuable data now available, would be generally adopted, and would save the investigators of the future much labor in reducing astronomical results to a uniform system of elements and constants. How far I shall have succeeded in this is yet to be seen; even now, before the work is printed, I am conscious of so many imperfections that I greatly regret my inability to do it over *ab initio*.

How great have been the administrative difficulties connected with its prosecution can well be judged by others. They have been intensified by errors of judgement in the choice of methods of work, and system of prosecuting it.

My personal attention has been mainly devoted to the elements of the four inner planets. The theories of *Jupiter* and *Saturn* were left entirely in the hands of Mr. HILL, whose work is already published in Vol. IV of the *Astronomical Papers*, while *Uranus* and *Neptune* have so far only been considered incidentally. I shall therefore, in the present paper, speak mainly of the four inner planets, and of the principal astronomical constants.

The provisional elements and masses of the inner planets employed for correction were those of LEVERRIER. They were preferred not only on account of their probable approach to precision, but also because, having been widely adopted in European ephemerides since 1864, it was supposed that a large amount of labor would be saved by their adoption. As, however, observations before 1864 had to be compared with the tables, it was necessary to extend the ephemerides back to 1750. As LEVERRIER's tables in their published form were extremely laborious in use, they were reconstructed in a more convenient form. In the reconstruction only tenths of seconds were included in the perturbations, since the errors arising from the omitted decimals would be accidental in their character, and would probably completely compensate each other in any extended series of comparisons. From such provisional tables of the sun a complete ephemeris of the longitude and radius vector for five-day intervals was computed from 1750 to 1864, the lunar term being omitted, to be afterward applied when necessary.

With the places of the sun thus derived, geocentric places of the planets were computed. The system of doing this varied greatly with circumstances. Existing ephemerides were utilized as far as possible. Sometimes the geocentric places were computed for the moments of observation; sometimes an ephemeris for equidistant dates was computed, and the tabular places interpolated. As all computations not admitting of control had to be in duplicate, it was judged best that the duplicate computation should, so far as possible, be made by a different method from the original one. This diversity of method was productive of so much trouble when it was necessary to compare or test results, that, had I to do the work over again, I should proceed on some nearly uniform system in all the computations.

Through misinterpretation of a remark of LEVERRIER, in the introduction to his tables of *Venus*, I overlooked the diversity of masses employed in his tables until the work was well under way. Since the provisional theory, to be correct, must necessarily be founded on a uniform system of masses, it was necessary to correct the places in all the ephemerides so as to reduce them to the provisional masses of LEVERRIER, in the second volume of his *Annales de l'Observatoire de Paris*. This involved a computation not only of the perturbations in heliocentric longitude and radius vector, but also of their effects on the geocentric place. It also became necessary to correct the ephemeris of the *Sun* to reduce it to HALL's mass of *Mars*, the provisional tables having been constructed with LEVERRIER's mass.

As to the reduction of observations, it will suffice to say here, in a general way, that they were all reduced to my own system of right-ascensions, and to Boss's system of declinations, by methods which varied with the circumstances.

The excesses of the individual observations over theory were divided into groups, in the usual way, the mean residual of each group being taken as the correction to the tables at the mean epoch of the group.

In the case of *Mercury* and *Venus*, the coefficients of the equations of condition were taken from tables of double entry. These tables were founded on those of single entry, given in Vol. II of the *Astronomical Papers*. The coefficients for *Mars* were computed from tables of single entry, like those just referred to.

A statement of certain features of the plan will be found in the introduction to Vol. I of the *Astronomical Papers*. One of these was the determination of the elements of the *Earth's* orbit not only from observations of the *Sun*, but from those of each of the other three planets. Except for the determination of the *Sun's* mean longitude, and the right-ascensions of the fixed stars, the results of this plan were not up to my expectations. One reason for this is a pleasing one; the eccentricity and perihelion of the *Earth's* orbit from observations of the *Sun* came out with a degree of precision and accordance far beyond my expectations. On the other hand, the results for the same quantities from the observations of the planets were disappointingly uncertain, from two causes. One was that the eccentricity and perihelion of the *Earth's* orbit cannot be determined so as to be wholly independent of those of a planetary orbit, from observations on the planet. The other cause was a singular anomaly in the observed right-ascensions of *Mercury*, which I have not yet had time to investigate. All the observations of this planet were reduced from the part observed, whether limb or apparent center, to the geometrical center, using a semi-diameter at distance 1, of 3″.34. This value seems very accurately determined by consistent observations both of the planet when off the sun, and when in transit over the Sun's disk. When the reduction was explicitly stated to have been made by the original observatories, it was omitted; otherwise it was always applied.

But on comparing the results from the two limbs of the planet, it was found that near the times of greatest elongation there was a difference in the excess of observed over tabular R.A. of nearly 2″, according as the planet was east or west of the sun. To reconcile this discrepancy by a correction to the diameter of the planet, it would be necessary to increase this quantity by 2″, that is, by nearly one-third of its whole amount. The injurious effect of this discrepancy upon the results was to a certain extent obviated by the introduction of an unknown quantity expressive of a possible correction to the ratio of the major axes of the orbits of *Mercury* and the *Earth*.

It may be remarked that the introduction of the *Sun's* elements into the equations derived from the planets was a necessity, unless the definitive solar elements had been determined in advance, which could not be done. The result of the plan adopted is that the definitive elements of the planets can be fitted in with the definitive elements of the *Sun*, so as best to satisfy all observations.

In the equations of condition from observations of the planets were also included the constant corrections to the equinox, and to the position of the *Earth's* equator on the celestial sphere; in other words, the common errors of the right-ascensions and declinations of the stars. This course is especially necessary, because the determination of these quantities in the usual way is unsatisfactory. It is well known that systematic differences exist between the absolute declinations of stars near the equator, as determined at different observatories, even with the best instruments. We cannot safely assume that this error would be eliminated by taking the mean of the work at all the observatories, because it may arise from some cause common to all. It cannot be doubted that the undisturbed orbit of each planet as seen from the sun forms a great circle on the celestial sphere. This fact enables us to determine the mean or common correction to all the stars within the zodiacal limits; or, to speak more exactly, within say, 25° of the equator, by introducing as an unknown quantity a common error of all the observed declinations.

That the equinox can also be determined from observations of a planet may be seen by the reflection that, were the elements of the planet perfectly known every observation of it could be reduced to the center of the *Sun*, so as to get an observed position of the *Sun* itself. Thus can be obtained corrections to the *Sun's* absolute longitude, and to the right-ascensions of the stars relative to its center, in the same way as from observations of the *Sun* itself. Moreover, this method has the great advantage of diminishing personal error in observing the transit of the Sun's limb, which enters as so great a disturbing cause in the determinations of absolute right-ascensions of the stars. Although the observations of the limbs of *Mercury* and *Venus* may be subject to the same error, I conceive that its probable value will be much smaller than in the case of the *Sun*. Especially will this be true of *Mercury*.

To give an idea of the consistency of the results, I give the corrections to the principal solar elements and to their secular variations for 1850, as derived from observations of the *Sun* and of each planet. The relative weights assigned are not determined by the theory of least squares, but by a consideration of the systematic errors to which the results are liable. These affect elements in very different degrees. The planets give poor results for the correction to the *Earth's* eccentricity and perigee; but better ones to the obliquity, and still better ones to the relative right-ascensions of the *Sun* and stars and to the *Sun's* absolute longitude.

The results from *Mars* are defective from the fact that this planet is not observed all round its orbit, but mostly when near opposition. The *Earth's* eccentricity and perigee can therefore scarcely be determined from it, and the determination of the other elements has yet less weight.

In the following table of results, $\delta\varepsilon$ represents the correction to the obliquity, $\delta L''$ to the absolute longitude of the Sun, and δA to the right-ascensions of the stars. The small figures following each result represent the relative weight assigned. T is the time from 1850, in terms of the century as the unit.

	$\delta e''$		$e''\delta\pi''$		$\delta\varepsilon$		$\delta L''$		$\delta(A-L'')$	
	″	″	″	″	″	″	″	″	″	″
Sun	$+0.10_{10}$	$+0.23_5\,T$	0.00_{12}	$+0.32_5\,T$	-0.30_{10}	$+0.48_{10}\,T$	$+0.05_4$	$-0.97_1\,T$	$+0.02_2$	$+0.63_2\,T$
Mercury	$+0.48_1$	$+0.32_1$	-0.47_1	-0.29_1	$+0.13_2$	$+0.39_2$	$+0.07_1$	-1.26_1	-0.60_3	$+2.05_3$
Venus	$+0.06_2$	$+0.32_1$	-0.07_2	$+0.46_1$	$+0.13_2$	$+0.32_2$	-0.16_1	-1.06_1	-0.34_2	$+1.20_2$
Mars	-0.83_0		-0.82_0		$+0.25_1$	$+1.03_1$	$+0.24_0$		-1.18_0	
Mean	$+0.12$	$+0.26\,T$	-0.04	$+0.25\,T$	-0.15	$+0.48\,T$	$+0.02$	$-1.10\,T$	-0.33	$+1.40\,T$

It will be seen that the common correction to the right-ascensions of the stars is

$$\delta A = -0^s.021 + 0^s.020\,T$$

The difference between the system used and that of the *Berliner Jahrbuch* is (approximately)

$$N - B.J. = -0^s.016 + 0^s.070\,T$$

The correction to the *B.J.* system therefore comes out

$$\delta \cdot B.J. = -0^s.037 + 0^s.090\,T$$

It requires a more careful comparison than I have made, to determine the exact amount of the difference between the two systems. The number just given is probably within two or three thousandths of a second for 1850; but the secular variation may be different by ±0s.01, or even more.

It is of interest to notice that although the above correction to my own system of right-ascensions brings it more nearly into accord with that derived from the Greenwich observations, on which the adopted star positions very largely rest, it is nevertheless brought about almost entirely through the observations of the planets. Had observations of the *Sun* alone been used, the correction would have been practically zero for 1850, and the secular correction $-0^s.023$ for my system, and about $+0^s.05$ for that of AUWERS.

The common correction to the declinations was determined not only from all three planets, but also from the observations of *Jupiter* and *Saturn*. Mr. HILL, in the introduction to his tables of those planets, gives the equations of condition for Δ and δ; I have, however, solved them anew with a different system of weights, separating the results of the two planets. They are as follows:

			″	″	Wt.
From obs. of *Mercury*,	δ decl.	=	$+0.18$	$+0.49\,T$	2
Venus,			$+0.19$	$+0.00\,T$	1
Mars,			$+0.21$	$+0.23\,T$	4
Jupiter,			$+0.04$	$+0.43\,T$	3
Saturn,			-0.04	$+0.68\,T$	4
Mean correction		=	$+0.09$	$+0.42\,T$	
Adopted "		=	$+0.08$	$+0.50\,T$	

Here I conceive that there can be no doubt as to the precision of the correction for 1850; but in deciding upon the final value of the secular variation to be adopted it may be considered advisable to give some weight to the observations of the stars themselves; more especially as a common error in all the declinations will be eliminated from the secular variation. I find that the observations of the stars, show a yet larger correction to the secular variations of Boss's declinations than the value 0″.42 given by the planets. Hence, in determining the elements of the planets I used 0″.50 for this variation.

Not having made a comparison of the Boss system with that of AUWERS, I cannot give the resulting correction to the latter, but believe that its value for 1850 will be very small, and its secular variation negative. Thus the preceding result lies between the results of AUWERS and BOSS.

It seems very desirable that those astronomers who are engaged in preparing fundamental positions of the fixed stars for use in geodesy and astronomy should agree upon some standard of right-ascensions and declinations, and also, if practicable, upon the fundamental positions of the individual stars to be adopted. I therefore submit the above results, with the hope that they will elicit some expression of opinion from those interested.

Although the fundamental elements for the planetary tables which I am now constructing cannot be altered, there is no necessity that the preceding corrections to the positions of the stars should be accepted without any change whatever. It is, indeed, desirable that the values of the fundamental constants to be used should all be adjusted and harmonized with one consistent theory, or, to speak with more precision, should be adjusted to one and the same system of values of the fundamental absolute constants which determine the motion of the earth, both on its axis and around the *Sun*. But no confusion will result from deviations which merely imply different interpretations of observations, or other-differences not inconsistent with uniformity of theory. Now, there is no necessary connection between the positions of the stars and those of the planets. The worst result that could happen from the adoption of fundamental corrections to the right-ascensions and declinations different from the preceding ones is that in the course of the twentieth century the tabular right-ascensions of all the planets would be found growing too small or too great. But this result may be anticipated in my case, as an inevitable effect of the imperfections in the values of the mean motions and other elements.

Another feature of the plan was the method of determining and adjusting the masses and secular variations. It being well known that the secular motion of the perihelion of *Mercury* does not coincide with theory, we may well fear that the same may be true of the other elements, and therefore, in the first instance, I did not attempt to determine the masses of the planets from the secular variations. Instead thereof the masses were determined independently of the secular variations, and then the results of the comparison of the observed secular variations with those resulting from the masses so determined were investigated. Hence the determination of each mass by some method which should be independent of the secular variations was an important requirement of the problem.

The mass of *Mars* is known with all necessary precision from Professor HALL's determination by the aid of the satellites. It therefore required no discussion.

The mass of *Venus* can be determined with fair precision by the periodic perturbations which it produces in the motions of the other planets, in such a way as to be free from all systematic errors whatever, how large soever the accidental errors may be. This follows from the fact that there is no relation between the periods of these perturbations and those of the other causes which may produce systematic error.

The mass of *Mercury* may be determined in the same way, from the periodic perturbations which it produces on *Venus*, as well as from other sources. Practically, however, the probable error of the determination proves to be quite large.

The mass of the *Earth* cannot be determined free from systematic error by the periodic perturbations which it produces in the other planets, because these perturbations depend upon the relative position of the two bodies, and may, therefore, have a period in common with the causes of systematic error. But it can be determined with sufficient precision from the value of the solar parallax.

I now pass to a discrepancy which has during the past four months caused me more embarrassment and trouble than all the other questions growing out of the work. Omitting the secular motions of the perihelia, which in the case of *Mercury*, and possibly of the other planets, are affected by some unknown cause, I examined the question what values of the masses would best represent the observed secular variations. The result is as follows. I first give the values of the correcting factors for the masses, as determined independently of the secular variations, together with their mean errors. That is to say, the masses are represented in the following form:

$$\begin{array}{lll} \textit{Mercury}, & m & = \dfrac{1+\nu}{7{,}500{,}000} \\ \textit{Venus}, & m' & = \dfrac{1+\nu'}{410{,}000} \\ \textit{Earth}, & m'' & = \dfrac{1+\nu''}{327{,}000} \\ \textit{Mars}, & m''' & = \dfrac{1+\nu'''}{3{,}093{,}500} \end{array}$$

For the four values of ν were obtained

from the Secular Variations	from other sources
$\nu = +0.07 \quad \pm.15$	$\nu = +0.08 \quad \pm.20$
$\nu' = +0.0100 \quad \pm.0056$	$\nu' = +0.0080 \quad \pm.0028$
$\nu'' = -0.0183 \quad \pm.0026$	$\nu'' = -0.0038 \quad \pm.0015$
$\nu''' = -0.015 \quad \pm.067$	$\nu''' = +0.004 \quad \pm.018$

It will be seen that, the *Earth* excepted, the two sets of values for the masses agree far within the limits of the probable errors, which are formed by multiplying the above mean errors by 0.6745. Moreover, the secular variations are, in the general mean, represented within their probable errors, except in the case of the eccentricity of *Mercury*, which we may well suppose to be affected by the defective results of the meridian observations already described.

Very different is it in the case of the *Earth*. To obtain the mass it was necessary, in accordance with what has already been said, to derive the best value of the solar parallax from all sources. With a single exception, which I shall mention subsequently, there was a remarkable concensus, showing the value of the parallax to be very nearly 8″.800. The probable error of this result could not be made to appear greater than 0″.004, even by a liberal allowance for all discordances. To this value of the parallax corresponds the first value of ν'', given above.

If, however, we derive the value of the solar parallax from the value of ν'' given by the secular variations, the result is

$$\pi = 8''.759 \pm 0''.010$$

To this mean error corresponds the probable error ±0″.0067. Moreover, this result appears to be of the most certain kind, both in the general accordance and the reliability of all the data on which it depends.

I have tried in vain to conceive or to invent any cause explaining this difference, other than the actual errors of the determinations. As the discussion will appear pretty fully in the forthcoming monograph, I shall here mention only a single curious coincidence. If, in computing the secular variations, the mass of the moon had been neglected, and that of the *Earth* alone taken into account, the discrepancy would not have appeared.

I have already remarked in the *Astronomical Journal* that the discrepancies may also be explained on the hypothesis of a group of planetoids just outside of the orbit of *Mercury*. This position of the group is more likely than a position nearer the *Sun*, because the nearer we place any such disturbing matter to the *Sun*, the greater must be its mass, and the greater would be the quantity of light which every unit of mass would reflect. But it seems to me impossible that a group of the required mass could remain invisible.

What I finally decided on doing was to change the value of each mass, as determined independently of the secular variations, by as great an amount as appeared to be admissible, and in such a direction as to best represent the secular variations. For the solar parallax I adopted as the value to be used in the tables,

$$\pi = 8''.790.$$

If we combine all the results by least squares, we shall get results which may range from 8″.775 to 8″.790, according to the relative weights we assign to the two systems of determining the parallax, or rather to the allowance we make on account of systematic errors in the various methods of determining it.

To the value 8″.790 of the parallax corresponds, for the constant of aberration, the value 20″.501. But, should we adopt the value 8″.780, which I am inclined to think the most probable, in case that no unknown cause has acted on the motions of the inner planets, then the constant in question would be 20″.524.

It is very remarkable that this value agrees with Nyrén's best result, though it is very much larger than the general mean of all the others. Still we must admit that this constant is one into the determinations of which systematic errors are most likely to enter.

The adjusted value of the constant of lunar nutation is

$$N = 9''.214 \pm 0''.005$$

The motion of precession is discussed so fully in the monograph that it seems unnecessary to say anything of it here.

ON THE LIGHT-VARIATIONS OF 7149 *S SAGITTAE*,

By EDWIN F. SAWYER.

The very interesting communication of Mr. Yendell, in *A.J. No. 321*, in reference to the peculiarities shown in the light-curve of this star, has caused me to reduce anew all my observations, 324 in number, made during the years 1886 to 1890 inclusive, and the years 1892 and 1893. A new light-curve has been formed from all the observations, using Dr. Chandler's elements given in his Second Catalogue. The comparison-stars used differ somewhat from the list employed by Messrs. Chandler and Yendell. These, together with the light-scale and deduced magnitudes, are given below.

DM. stands for the Bonn *Durchmusterung*; M.K., for the new photometric Catalogue of Müller and Kempf; S, for my own determinations of magnitude.

Comparison-Stars.

Star	Name	DM.	M.K.	S	Light
		M	M	M	st.
a =	*η Sagittae*	5.5	5.04	5.1	20.6
b =	F. 11 "	5.8	5.67	5.45	15.8
c =	ε "	5.2	5.67	6.1	9.3
d =	DM. 14°3974	6.5	6.68	6.8	2.7
e =	DM. 16°4086	7.0	7.13	7.0	0.0

Inasmuch as some irregularity evidently exists in the light at the maximum phase to be spoken of hereafter, I have thought it best to reduce my observations to the epoch of minimum, although the less favorable situation of comparison-stars, and an apparent slight fluctuation in brightness at minimum, render this phase somewhat less certain of determination. The residuals in the column O−C given below are from comparison with Chandler's elements:

Observed Minima.

E	Boston M.T.	O—C	Wt.	E	Boston M.T.	O—C	Wt.
		d				d	
426	1886 Sept. 20.186	−0.057	3	438	1886 Dec. 29.728	−0.114	1
427	29.317	+ .691	2	461	1887 July 10.875	+ .220	1
428	Oct. 6.921	− .088	3	462	18.785	− .253	2
429	15.819	+ .426	2	463	27.666	+ .244	1
430	23.762	− .014	5	465	Aug. 12.855	− .333	2
431	Nov. 1.753	+ .594	2	468	Sept. 7.433	+ .095	1
432	9.100	− .442	2	469	15.746	+ .025	3
433	17.830	− .095	3	472	Oct. 11.203	+ .333	3
434	26.576	+0.267	3	473	18.470	− .784	1
436	Dec. 14.150	+1.075	1	475	Nov. 5.398	+ .378	3
437	20.915	−0.543	3	476	13.021	−0.382	1

E	Boston M.T.	O—C	Wt.	E	Boston M.T.	O—C	Wt.
		d				d	
477	1887 Nov. 22.031	+0.245	2	557	1889 Sept. 22.958	+0.516	2
478	30.428	+ .258	1	593	1890 July 20.406	— .831	1
500	1888 June 1.430	— .170	1	687	1892 Sept. 16.419	+ .161	3
501	10.077	+ .094	2	688	24.672	+ .030	1
502	17.695	— .671	1	689	Oct. 3.069	+ .044	2
503	26.925	+ .175	1	690	11.545	+ .137	3
504	July 5.159	+ .026	2	693	Nov. 5.890	+ .332	1
505	14.297	+ .781	2	694	13.610	— .331	1
507	30.953	+ .671	1	695	21.909	— .415	3
510	Aug. 24.700	+ .268	1	699	Dec. 8.890	— .200	1
511	Sept. 1.707	—0.108	1	722	1893 July 6.496	— .174	2
514	27.980	+1.015	2	723	14.768	— .286	2
515	Oct. 5.627	+0.279	1	724	23.713	+ .276	3
518	30.383	— .115	1	726	Aug. 9.455	+ .252	2
519	Nov. 8.542	+ .661	1	727	17.967	+ .381	1
522	Dec. 2.603	— .427	1	729	Sept. 3.462	+ .109	2
546	1889 June 22.427	+ .200	2	730	12.245	+ .509	3
549	July 17.013	— .364	3	733	Oct. 6.680	— .206	2
550	25.904	+ .144	2	734	15.415	+ .146	2
551	Aug. 2.812	— .331	1	736	Nov. 1.427	+ .392	2
552	11.533	+ .007	1	737	9.224	— .194	2
554	27.981	— .312	4	739	25.726	— .458	2
556	Sept. 14.106	+0.047	1	740	Dec. 4.109	—0.459	1

The mean yearly residuals are given in the table below:

MEAN.

Year	Epoch	O—C	Wt.
		d	
1886	431.5	+0.063	30
1887	470.0	+0.056	21
1888	509.0	+0.244	18
1889–90	564.5	—0.102	17
1892	692.0	—0.029	15
1893	731.0	+0.055	26
Mean	566.0	+0.048	21

In forming the mean light-curve the same process as used by Mr. YENDELL has been employed, and the list of normals so formed is given below for comparison. The departure of the normals from the light-curve as finally drawn is expressed in steps of the light-scale in column *Diff.*

TABLE OF NORMALS.

Time	Light	Diff.	Time	Light	Diff.
d	st.	st.	d	st.	st.
—3.73	4.24	—0.22	+0.46	13.57	—0.13
—3.44	5.00	+0.58	+0.86	14.00	+0.20
—3.21	4.37	—0.05	+1.11	13.81	—0.29
—2.85	4.51	—0.14	+1.36	14.35	—0.01
—2.57	5.43	+0.02	+1.72	13.67	+0.02
—2.40	6.11	+0.16	+1.97	12.56	+0.01
—2.21	7.12	+0.39	+2.33	10.94	—0.18
—1.97	7.40	—0.70	+2.67	10.23	+0 33
—1.71	11.42	+0.92	+2.91	9.05	+0.25
—1.34	12.97	—0.43	+3.13	7.48	—0.22
—1.03	14.85	—0.15	+3.55	6.16	+0.01
—0.84	15.68	+0.08	+3.99	5.23	—0.01
—0.55	15.73	—0.17	+4.31	4.84	+0.11
—0.21	15.49	—0.06	+4.66	4.24	—0.21
±0.00	14.55	—0.25	+4.94	5.00	+0.60
+0.16	14.47	+0.12	+5.17	4.37	—0.13

The average departure of the curve from the normals is $0^{st}.223$. These normals indicate strongly, as do Mr. YENDELL's, a small depression of the curve; but in my curve this depression occurs about $0^d.55$ after the computed place of maximum instead of at maximum as shown by Mr. YENDELL's results. This depression is also less pronounced in my curve than in his, and while he finds the second maximum slightly brighter than the first, my results show the first to be decidedly the brighter of the two. Notwithstanding the fact that a depression is undoubtedly shown in both our mean light-curves, I am led to believe from a careful inspection of several single curves, where observations for several consecutive days near maximum have been secured, that this is partially due to errors of observation, and partially to the fact that sometimes the light at maximum remains practically at a standstill for a day or more exhibiting a flat curve, while at other, and perhaps alternate, maxima the rise and fall is quite sharp; the mean of the two producing an apparent depression. The above fact is strongly supported by four well observed maxima in the past year (1894). The first maximum, August 24, from 10 consecutive observations, August 19 to 28 inclusive, shows a sharp rise from minimum, a slight standstill at maximum, and a gradual but uniform decrease. The second, September 21, from 9 consecutive observations, September 21 to 29 inclusive, exhibits a sharp and uniform rise, a decided standstill for two days after maximum and a sharp fall. The third, December 4, from 5 observations, 4 consecutive, December 1 to 6, shows a somewhat more gradual rise to maximum and a decidedly sharp fall afterwards. The last, December 19, from 7 consecutive observations, December 17 to 23 inclusive, shows a rapid rise, and a somewhat slow, but certain, progressive fall from maximum. Observations made under the same conditions in the years 1886, 1887 and 1892, exhibit the same phenomena. The observations during the past year were very carefully made for the express purpose of confirming the conclusions arrived at by Mr. Yendell, with the results noted above. It is especially important in the case of this star, that the observations near maximum should be made with extreme care, as, at its brightest phase *S* appears very slightly brighter, about one step, than the close adjoining comparison-star F. 11 *Sagittae*. If made with care and under favorable conditions for two consecutive days at maximum the observations will at times show *S* to be slightly brighter than F. 11 *Sagittae* on the first day and as distinctly fainter on the second day, thus exhibiting an actual, though slight, fall from maximum and not as hastily observed under less favorable conditions, showing an apparent standstill in the light for ten or more days; this being the case when the the two stars are adjudged to be of equal brightness during both days. Unfortunately the star has approached so near the sunset-horizon that it will not be possible until another season to determine whether the phenomenon presented consists of alternate short and prolonged maxima, or whether these occur without any regularity of order.

In the curve indicated by the normals, the minimum occurs at −3.34 days; a sharp uniform rise from minimum is followed by the principal maximum at −0.55 days and a very slight rise or secondary maximum at +1.35 days. After the secondary maximum the fall is quite rapid and generally uniform. The readings from the adopted mean light-curve are as follows:

Reading from Mean Light-Curve.

Time	Light	Time	Light	Time	Light	Time	Light
d	st.	d	st.	d	st.	d	st.
−3.34	4.40	−1.20	14.18	+1.00	13.85	+3.20	7.35
3.20	4.41	1.00	15.07	1.20	14.25	3.40	6.58
3.00	4.48	0.80	15.67	1.40	14.30	3.60	6.00
2.80	3.73	0.60	15.88	1.60	13.95	3.80	5.59
2.60	5.30	0.40	15 80	1.80	13.35	4.00	5.22
2.40	5.95	−0.20	15.52	2.00	12.50	4.20	4.90
2.20	6.70	±0.00	14.80	2.20	11.60	4.40	4.62
2.00	7.86	+0.20	14.20	2.40	10.88	4.60	4.48
1.80	9.58	0.40	13.78	2.60	10.18	4.80	4.42
1.60	11.55	0.60	13.67	2.80	9.34	+4.98	4.40
−1.40	12.98	+0.80	13.75	+3.00	8.32		

Limits of variation: { Maximum light = 15.90 = 5.40 M
{ Minimum light = 4.40 = 6.55

Brighton, 1895 *January* 14.

OBSERVATIONS OF ENCKE'S COMET,

MADE AT THE UNITED STATES NAVAL OBSERVATORY WITH THE 9.6-INCH EQUATORIAL,

By Prof. EDGAR FRISBY.

[Communicated by Prof. Wm. Harkness, U.S.N., Astronomical Director.]

1894–95 Washington M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Dec. 19 7 0 17.5	1	20 , 4	+4 42.24	− 1 13.3	22 16 53.87	+4 35 56.1	9.4666	0.7079
20 6 39 17.1	2	5 , 4	−2 23.48	− 2 47.0	22 16 38.93	+4 28 55.8	9.4246	0.7049
6 49 7.2	3	16 , 4	+0 31.70	− 1 34.5	22 16 38.77	+4 28 47.4	9.4246	0.7049
22 7 40 44.9	4	27 , 6	−3 58.65	+ 1 21.5	22 16 11.11	+4 11 31.4	9.5773	0.7178
23 6 31 34.3	4	20 , 4	−4 13.70	− 5 13.0	22 15 56.05	+4 4 56.8	9.4471	0.7094
Jan. 14 7 16 29.5	5	25 , 5	+0 3.45	+10 32.3	22 3 20.48	−0 0 2.5	9.6419	0.7424

Mean Places for 1894.0 and 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	22 12 9.27	+2.36	+4 36 53.9	+15.5	Albany A.G.Z. 7744
2	22 19 0.03	+2.38	+4 31 27.1	+15.7	Albany A.G.Z. 7761
3	22 16 4.71	+2.36	+4 30 6.3	+15.6	Albany A.G.Z. 7754
4	22 20 7.38	+2.38	+4 9 54.2	+15.7	Albany A.G.Z. 7767
5	22 3 17.81	−0.78	−0 10 28.7	− 6.1	W. Bessel, Copel.-Börgen, Munich (2)

OBSERVATIONS OF ENCKE'S COMET,

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

1894 Cincinnati M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Dec. 17 7 21 11	1	8	+1 41.44	+3 29.3	22 17 26.07	+4 50 16.5	9.493	0.708
19 7 28 34	2	8	+4 41.30	−1 41.4	22 16 52.93	+4 35 28.0	9.523	0.713
21 7 44 30	3	6	+0 15.95	−9 5.9	22 16 23.02	+4 21 15.9	9.562	0.718
7 44 30	4	4	−3 46.02	+8 10.7	22 16 23.74	+4 20 59.9	9.562	0.718
25 6 57 44	5	8	+1 1.63	+2 36.0	22 15 30.56	+3 52 56.2	9.512	0.717
28 7 28 22	6	8	+1 16.63	−6 16.5	22 14 48.56	+3 30 45.6	9.580	0.725
31 6 20 12	7	8	−1 39.83	−1 53.3	22 14 2.08	+3 7 23.8	9.486	0.722

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	22 15 42.23	+2.40	+4 46 31.2	+16.0	DM. 4°4845 eq. comp. with Boss A.G. 7733
2	22 12 9.27	+2.36	+4 36 53.9	+15.5	Boss A.G. 7744
3	22 16 4.71	+2.36	+4 30 6.3	+15.5	Boss A.G. 7754
4	22 20 7.37	+2.39	+4 12 33.5	+15.7	Boss A.G. 7767
5	22 14 26.59	+2.34	+3 50 5.3	+14.9	11ᴹ comp. with Boss A.G. 7747 and 7756
6	22 13 29.60	+2.33	+3 36 47.5	+14.6	Boss A.G. 7746
7	22 15 39.58	+2.33	+3 9 2.8	+14.3	Boss A.G. 7752

NOTE. — On Dec. 21 the wind disturbed the telescope, so that some comparisons had to be rejected, and the remainder are not very trustworthy.

The following is a comparison with the ephemeris in *A.N.* 3263, O—C.

	Δα	Δδ		Δα	Δδ
	s	″		s	″
Dec. 17	−0.10	−13.1	Dec. 25	+0.50	−8.6
19	0.00	−19.6	28	+0.09	−5.2
21	+0.24	−13.5	31	+1.34	−4.5

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